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## TRAVELS AMONG THE GREAT ANDES OF THE EQUATOR.*

By T. G. Bonney.

Mr. Whymper's expedition to the Great Andes of Ecuador occupied him from December, 1879, to July, 1880. The results were briefly indicated in communications to the Royal Geographical Society and the Alpine Club, but the full description has been long in coming. Horace recommended giving literary work nine years to ripen; Mr. Whymper has more than followed his advice. Possibly the delay may be a mistake from a commercial point of view, but it is a gain to the readers when a book of travel in an interesting region is not written in a hurry and rushed through the press, but is rendered complete in every detail with an almost loving care.

The principal object of Mr. Whymper's journey was to observe the effect of greatly diminished atmospheric pressure on the vital powers. There was already very strong cumulative evidence that, at elevations of rather more than 14,000 ft. above the sea, serious inconveniences were very often felt, such as difficulty of breathing, acute headache, a sense of extreme prostration, and sometimes hemorrhage. Some of the symptoms, some of the suffering on record, might doubtless be attributed to other causes; still the connection between "mountain sickness" and diminished air pressure appeared to be indubitable. The problem had already been investigated, so far as could be done in the laboratory, by M. Paul Bert, and an account of his experiments forms an appendix to Mr. Whymper's book. Balloon ascents also had been made, one with disastrous results: for of three aeronauts who had remained for some time at a height of from 26,000 to 28,000 ft., two had died, and the other had narrowly escaped with his life.

But a balloon ascent is an unfairly severe test, since the atmospheric pressure is so rapidly diminished; so Mr. Whymper determined to encamp for some time at an elevation at which others had begun to suffer, and from that level to "carry exploration and research up to the highest possible limits." The Himalayas were at first selected as the place for these investigations, but, before he could start, the attempt to construct a "scientific frontier" aroused so many jealousies that, in all probability, the experiments and the life of the operator would have been simultaneously cut short. War also forbade travel in the very highest region of the Andes, so that ultimately the mountains of Ecuador were selected as the most lofty accessible district.

Chimborazo being the culminating peak of this group, the ascent of this was the main object of Mr. Whymper's expedition. He determined to encamp on its slopes at gradually increasing heights, with the aim of ultimately reaching the summit. "But as there was no certainty that this could be done, and a possibility, at least, that the results of the investigation might be of a negative character, various other objects were kept in view, chief among them being the determination of the altitudes and relative positions of the principal mountains of Ecuador, the comparison of boiling point observations and of aneroids with the mercurial barometer, and the collection of specimens, botanical, zoological, and geological, at great heights." Mr. Whymper was accompanied by two Alpine guides—one being the well known Jean-Antoine Carrel, of Val Tournanche, whose sudden death on the Matterhorn in 1890 was so generally regretted among mountaineers; the other, his cousin Louis. Of their services and willing help at all times, he speaks in the highest terms. Chimborazo had been attempted without success by Humboldt and by Boussingault; Cotopaxi had been ascended, but very few of the other high peaks in Ecuador, though many measurements of altitudes had been made by Drs. Reis and Stubel in 1871-73, who kindly placed their results at Mr. Whymper's disposal.

Mr. Whymper spent 212 days in the upland or mountain district of Ecuador. During 204 nights of this period the barometer never gave a reading higher than 22·31 in., or the observers were over 8,000 ft. above sea level; during 90 of these it ranged from 21·72 to 21·11 in. (9,000 to 10,000 ft.); during 36 it was 18 in. or less (above 14,000 ft.); during 19 it stood between 16 and 17 in. (15,801 to 17,285 ft.); and on one night the reading was 14·75 in., corresponding with a height of 19,500 ft. He landed at Guayaquil on December 9, and reached Guaranda (nearly 9,000 ft. above the sea) after crossing the Pacific range of the Andes, of which Chimborazo is the culminating point, by a pass about 10,400 ft. above the sea. In preliminary explorations on that mountain Mr. Whymper ascended to a height of about 12,900 ft., and his guides, on another occasion, to about 16,500; and his party left Guaranda to attempt the ascent on December 26. They passed the first night at a height of 14,375 ft., on the great sandy plain known as the Arenal, without feeling the slightest inconvenience from the diminished pressure, and the next day pitched the second camp at a height of 18,664 ft. (pressure 16·5 in.) This was reached without inconvenience, but the mules during the last six or seven hundred feet of the ascent had shown marked and unusual signs of exhaustion. Mules and drivers were sent back, and the explorers remained in excellent health and spirits, but about a couple of hours afterward all three were suddenly and almost simultaneously prostrated; their respiration became labored, "accompanied by spasmodic gasps or gulps," they suffered from acute headache, with feverish symptoms, and an "indescribable feeling of illness pervading almost the whole body. . . . The attack seemed to arrive at a maximum quickly, to remain equally intense for several hours, and then it died away imperceptibly." In about 36 hours the Carrels got better, and felt well enough, on the 29th, to set off for a preliminary exploration; they reached a height of about 19,300 ft., but were much exhausted when they returned in the evening. Mr. Whymper recovered rather more slowly, but during the whole time Mr. Perring, a native of the country, who remained with them at the camp, was unaffected. On January 2 they moved on to a height of 17,285 ft., and after an attempt next day, frustrated by bad weather, which appears to be almost chronic in the mountains of Ecuador, reached the summit (20,498 ft.) on January 4. The weather was still unfavorable, and the work laborious, but they progressed more slowly than they would have done under similar circumstances in the Alps. They remained at the camp until January 10—for Mr. Whymper contemplated another visit to the summit under more favorable conditions—but were then obliged to return to Guaranda, as Louis Carrel was suffering severely from the effects of frost bite.

Fig. 1.—CROSSING THE GREAT ARENAL.

How the investigation was continued may be read in the book. In addition to excursions to lower points, Mr. Whymper, with one or both of his guides, ascended the following mountains: Corazon (15,871 ft.), Cotopaxi (19,613 ft.), where they encamped for the night, close to the brink of the crater, Pinchincha (15,918 ft.), Sincholagua (16,365 ft.), Antisana (19,335 ft.), Cayambe (19,186 ft.), Sara-urcu (15,502 ft.), Cotocachi (16,301 ft.), and Carihuairazo (16,515 ft.), all but the first three being new ascents. The Carrels also reached the summit of Illiniza (17,405 ft.), and on two other occasions Mr. Whymper arrived within a few hundred feet of it. The expedition concluded with a second ascent of Chimborazo, when the travelers were favored with better weather, and with an exceptionally interesting incident. As they were mounting the slopes, Cotopaxi was full in view, nearly sixty miles away. Suddenly it ejected a column of "inky black smoke" to a height of about 20,000 ft. above the lip of the crater. At this elevation the cloud was caught by an easterly wind, and borne at right angles to its former course; then it was taken by a northerly current and carried down upon Chimborazo. When the party reached the summit, at 1:30 P. M., the snow was still perfectly white; but, before long, the dust began to fall thickly, shutting out all view, penetrating into instruments, and adding an unpleasing condiment to their food. It had taken rather more than 7½ hours on its aerial journey. During these excursions, neither Mr. Whymper nor his guides suffered any return of the severe symptoms which they had experienced on the flanks of Chimborazo; but he proves, by his careful and elaborate observations, that, though they became somewhat habituated to low barometric pressures, their bodily powers were sensibly diminished. In his own case this appeared to begin at pressure of about 21 in. (roughly, 10,000 ft. above the sea). He comes to the conclusion that, after some habituation, life can be sustained, when the body is at rest, at a height of 20,000 ft. or more; but "when in motion it becomes difficult to enlarge the breathing capacity to the extent necessary to meet the further demand for air which was the result of muscular exertion."*

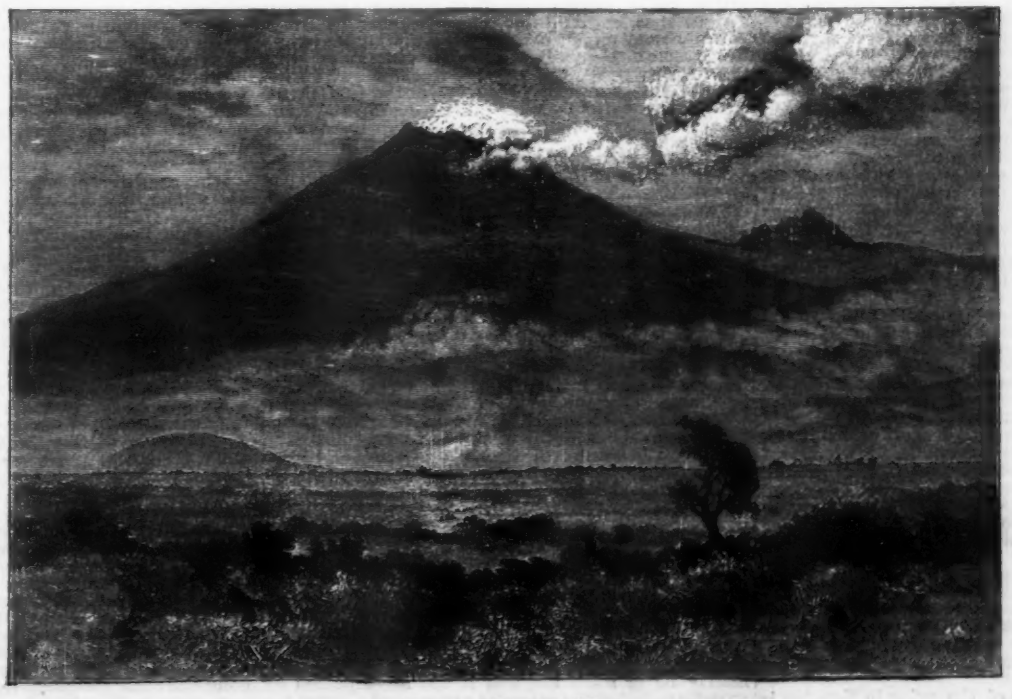


Fig. 2.—COTOPAXI.

During these laborious expeditions Mr. Whymper was constantly occupied in carrying out the other objects of his journey. The physical geography of the region was studied, sketch maps were constructed, and many specimens of rocks and volcanic dust were collected, especially from the higher points. The mountains (except Sara-urcu, the rocks of which are crystalline schists and gneisses) all consist of volcanic rocks, varieties of andesite. Cotopaxi and Sangai are still active; in some of the

* "Travels among the Great Andes of the Equator." By Edward Whymper. With maps and illustrations. London: John Murray, Albemarle street. 1892.—*Nature.*

* I have never suffered (when otherwise in good health) from mountain sickness in the Alps, but have often observed that I got "out of breath" more quickly in ascending peaks above 10,000 or 11,000 ft. This was especially noticed in an ascent of the Matterhorn, when, owing to threatening weather, I went as fast as possible up the last thousand feet or so.

others, even the craters cannot be distinguished. The glaciers were carefully observed, for Mr. Whymper has proved that, contrary to the received statement, glaciers are by no means rare in the Ecuadorian Andes. Botanical and zoological collections were made, especially from the higher localities.

Lichens were found as high as 18,400 ft., mosses to about 16,600 ft., grasses nearly as high, with a few Phanerogamous plants; the highest *Lycopodium* found was at 15,871 ft. *Coleoptera*, *Orthoptera*, *Rhynchota*, and *Lepidoptera* were all found at or a little above 16,000 ft., and *Arachnida* nearly as high. *Crustacea*, *Reptilia*, and *Batrachia* are rare; and Mr. Whymper could only obtain one fish (the noted *Cyclopium cyclopum*), which he does not believe to be ejected from Cotopaxi. These have been examined by various specialists, whose reports are summarized in the work, and some of them are collected in a supplementary volume, which will receive a separate notice. Mr. Whymper also made an interesting collection of stone implements and of ancient pottery, of which many specimens are figured. In one of the appendices he discusses the results of observations of mercurial and aneroid barometers. These, though of much interest, we must pass over.

In the space at our disposal it has been impossible to do justice to the varied topics of this volume. It must suffice to remark that Mr. Whymper has more than maintained the reputation which he won in his well known "Scrambles among the Alps." The present work is admirably written, clear and terse in style, and often enlivened with a spice of dry humor. Of the illustrations it is almost needless to speak; they are even better than those in the former book. Some are delightful renderings of comic incidents; others represent stone implements, pottery, insects, and various examples of the Ecuadorian zoology; others are pictures of the mountain scenery, including the upper part of Chimborazo and the summit crater of Cotopaxi. The book, in short, is not only a record of pluck and endurance (for the hardships, lightly as they are treated by Mr. Whymper, were often great), but also a literary success, and a contribution to science of no small value.

FIG. 3.—THE CONTENTS OF A GRAVE.

FIG. 4.—"THIS IS VERY OLD, SENOR."

## THE MAYA RACE IN CENTRAL AMERICA.

THE central portion of the peninsula of Yucatan has always been more or less a *terra incognita*. The Spaniards never really brought its inhabitants into complete subjection, and to this day it is peopled by hostile Indians, and no Spaniard dares to enter it.

If this country contains traces of the old civilization, nothing definite is known of them. The northern portion of the peninsula was brought completely under Spanish control, and is known to be studded with the remains of groups of ancient stone buildings.

It was on the northeast coast of Yucatan that the Spaniards first came into contact with Indians who used stone as a building material, and there can be but little doubt that some of the many ruined structures now to be seen were inhabited by the natives at the time of the conquest.

I am myself inclined to the opinion that the north of Yucatan was the last stronghold of the more cultivated branch of the Maya race after that race had either been driven out of, or under the stress of unknown adverse circumstances had retrograded in, the country to the south. But it does not follow that the Indians of Yucatan were at the height of their power and prosperity when the Spaniards came among them. In fact, their conquerors learnt from them that for some time previously the country had been troubled with civil wars and dissensions, and that Mayapan, once the chief town, had been destroyed and abandoned. It seems quite probable that this statement may be enlarged on to a considerable extent, and that we may consider the country to have been in a state of decadence, and that not one but many of the chief centers of population had been more or less abandoned. However, the temples and sacred edifices appear still to have been held in reverence after the population had moved away and were visited during festivals, and may have been kept in some sort of repair by the priests, much in the same way as I believe the ruined dagobas and temples at Pollonarua and Anuradhapura are reverenced and visited by the people of Ceylon.

This appears to me to have been most probably the case with regard to the important buildings which still mark the site of what must have once been the large town of Chichen Itza.

It has, I know, been stated that Chichen was inhabited at the time of Francisco de Montejo's first abortive effort to conquer Yucatan, and that the Spaniards were for some considerable time encamped in the town, but this statement does not appear to me to be supported by any sufficient evidence. Nevertheless, religious ceremonies had been so recently observed in Chichen Itza that, in answer to a dispatch from Spain, a committee of the settlers in the neighboring town of Valladolid were able to give some account of them in the year 1579.

My personal experience of the ruins in Yucatan is limited to a hasty visit to Labna and Uxmal, and a residence of five months in one of the ruined temples of Chichen Itza. At Chichen my clearings and surveys extended over an area of nearly a mile square, and although this appeared to include all the principal edifices, it was impossible to walk into the bush in any direction from the edge of this area without coming on the traces of stone buildings.

The surface of the ground, even in the center of the town, although generally level, was in some places composed of cavernous and broken limestone rock, and these portions had apparently been walled off as unfit for buildings. But, wherever the ground was suitable, there were numerous traces of slightly constructed buildings in addition to the more solid structures.

The hieroglyphic inscriptions at Chichen are few in number, and with one small exception very poorly carved, but there is enough to show that they did not differ in character from those in Guatemala and Chiapas. There is, however, one great distinction between the sculptures in Yucatan and the country to the south which must not be overlooked. In the latter there is almost an entire absence of weapons of war, and the figures of women occupy a prominent position. In Yucatan the change is complete; there are no women represented in the sculptures, and every man is a warrior armed with spears and throwing stick.

Whether the Maya civilization extended to Yucatan during the time that it flourished at Copan or Palenque, it is at present impossible to determine; but I strongly incline to the opinion that all the buildings now standing in Yucatan are of a later date. It may be perhaps allowable to state the case somewhat as follows:

That the civilized portion of the Maya race have at some time occupied all the country lying between the Isthmus of Tehuantepec and the western frontiers of Honduras and Salvador (excepting perhaps a strip of country along the Pacific seaboard); that this people spoke the same or nearly allied languages, which they wrote or carved in the same script; that they were followers of the same religion, and built stone-roofed temples and houses decorated with the same class of design and ornament.

That at the time of the Spanish conquest they had entirely abandoned all their towns and religious centers in the country to the south of Yucatan, although the good state of preservation of many of the buildings at the present time precludes the idea that this desertion of their towns could have antedated the arrival of the Spaniards by very many years. That the people whom the Spaniards encountered in this part of the country, although they may have been allied in blood to the Mayas, were undoubtedly in a lower state of culture, and that an examination of the sites of their principal towns yields no signs of the artistic culture which is universally found in the older ruins.

That in Yucatan, where the Spaniards found a dense population of Maya Indians, and encountered a fierce and stubborn resistance, there are still to be seen numerous remains of ancient buildings, both larger and in better preservation than those in Guatemala and Chiapas, but built in the same manner, decorated with the same ornaments, and with inscriptions carved in the same hieroglyphic script. That there is evidence from the early Spanish writings that some at least of those buildings were still occupied at the time of the conquest; but that both the observations of the Spaniards themselves, as well as the reports subsequently gathered by them from the Indians, point to the conclusion that the country was in a state of decadence, and that many of the larger centers of population had already been abandoned, although the more important religious edifices may still have been reverenced and kept in repair.

The early Spanish writers make frequent allusion to the large number of books written and preserved by the natives of Yucatan. These books were written in hieroglyphic characters in the Maya language, which, it must be remembered, is still spoken by the whole of the Indian population of Yucatan, as well as by nearly all the half breeds and Spaniards.

Unfortunately, every effort was made by the Spanish priests to destroy this literature, which they looked on as the work of the devil; and it is very doubtful whether a single fragment of hieroglyphic manuscript is now in existence in the whole peninsula.

One of the chief of the iconoclasts was Archbishop Diego de Landa; but, luckily, his zeal was tempered by a considerable appreciation of the ingenuity of the Indians, and an interest in their manners and customs which induced him to make some notes on their method of writing and recording events.

It is to this that we owe what is commonly known as "Landa's alphabet;" but, as this was an attempt to make an alphabet of a language which in all probability was not written alphabetically but syllabically, it was a signal failure, and has proved, to the few scholars who have attempted to employ it, about as puzzling as the hieroglyphics themselves. However, it may ultimately be of some use, and it was accompanied by an explanation of the calendar system, and a list of the signs for the days and months, with their names, which is of the greatest value.

Although no Maya books are known to exist in America, three examples of what are undoubtedly genuine Maya manuscripts have turned up in Europe.

No information whatever is forthcoming as to how they got here, but it is not unlikely that they were sent over as curiosities at the time of the Spanish conquest, and were afterward lost sight of.

They are the "Codex Troano," now preserved in the Archæological Museum at Madrid, a chromolithographic copy of which was published by the Abbe Brasseur de Bourbourg; the "Dresden Codex," preserved in the Royal Library at Dresden, of which a beautiful photolithographic copy has been published under the direction of Prof. Forsteman; and the "Codex Peresianus," in the Bibliotheque Nationale at Paris. Another manuscript at Madrid, which has been called the "Codex Cortesianus," appears to be only a detached portion of the "Codex Troano."

An examination which I have made of the two first mentioned codices leaves no doubt on my mind about the similarity of the written to the carved inscriptions. Many of the glyphs are identical, and others only vary as much as might be expected by the change from carving on stone to writing on paper. In addition to this evidence of the eyes, there is the distinct statement of Cogolludo, the historian of Yucatan, that the Indians had "characters by which they could understand one another in writing, such as those yet seen in great numbers on the ruins of their buildings."

So that we arrive at the important conclusion that the language of the carved inscriptions of Copan, Quirigua, and Palenque is still a living tongue, although it has doubtless been much changed in the course of years.—*Alfred P. Maudslay, in Nature.*

## THE BAMBOO.

### THE GENUS BAMBUSA AND ITS ALLIES.

By EUGENE MURRAY AARON, Ph.D.

WHAT to us, here in civilization, are the oak and pine and chestnut in timbers and iron and steel and brass in metals, is the bamboo tribe to the man of primitive life in tropical countries. Even more than this, for textile fabrics and food also are produced by these mighty grasses, and in some climes it seems as though they can be made to serve every absolute want. To that vast beehive of humanity dwelling within the limits of the tropical belt the bamboo supplies to those in the lower walks of life the fence around the garden patch, the dwelling—from corner post to clapboard—the sheds, water pipes, flower pots, cups, and other utensils, chairs and stools, tables, beds and hammocks, panniers for the willing donkey and the pliable incentive if he be not willing, food for him and for his master, and, as the æsthetic life slowly dawns, hedges and clumps of decorative effect without, as well as vases, frames and screens within.

The germs *Bambusa*, and the allied genera *Arundinaria*, *Arundo*, *Dendrocalamus*, *Gigantochloa*, and *Melocanna*, comprise many hundreds of species varying in size from the slender pampas grasses to *Gigantochloa Aspera* of Java, which Zollinger tells us has been measured in one case where it had reached the enormous height of 170 feet. Other species reach sizes almost equal to *Aspera*, among them being *Bambusa Spinosa* of Bengal, *Gigantochloa Maxima* of the Moluccas, which produces stems sufficiently large to split in two, so that each half will make a fair sized canoe, *Dendrocalamus Giganteus*, also a Moluccan species, rivaling *Aspera* in magnificent proportions, *D. Strictus*, often forming vast forests which average over 100 feet in height, *Gigantochloa Nigrociliata*, of India, reaching 130 to 140 feet, and *G. Robusta*, from the mountains of Java, a species which has been found to be 22 inches in girth 120 feet from the ground. It is difficult for one who has never dwelt within tropical limits to picture the enormous growths here mentioned: a grass, or a fishing rod if you will, that is over four feet in girth and that far overtops most city church spires, yet which maintains all the airy grace and decorative qualities of our ornamental grasses in its gigantic proportions, is a sight never to be forgot. Beautiful as are most of the palms, the bananas, exquisite as are the *Orchidaceæ*, and striking as are many of the large flowering trees, there are few dwellers in those regions who do not soon come to regard the bamboos as the chiefest decorative product of the tropical flora. But if the sizes attained by these plants are phenomenal, what shall be said of the rate at which the great heights are often reached? *G. Robusta* has grown 18 feet in a month; *B. Vulgaris* has grown 40 feet in one season; *B. Balcooa* was observed to grow 12 feet in 23 days; *B. Fulda* has grown from 20 to 30 feet in a month, and a common Chinese species, Fortune tells us, has been measured at the excessive rate of 2½ feet per diem. As this growth is principally confined to the ten hours of darkness, it would appear that it must be quite possible to actually see the motion of this growth of three inches per hour.

This very rapid growth, taken in connection with the generally graceful droop of the stems and frequently beautiful coloring of the delicate leaves, fit these plants for many decorative and useful purposes. The Dingala bamboo of the Himalayas is a hardy, rapid-growing pampas grass, which can be propagated from cuttings in the open air as far north as Washington. *Arundinaria Japonica*, well known to our gardeners, is a dwarf species, hardy in Southern England. *Arundo Bengalensis*, of China and India, has long panicles of beautifully variegated white and violet leaves. Its congener, *A. Conspicua*, of New Zealand and the Chatham Islands, is a choice plant for the use of the landscape gardener. The bamboo reed of Southern Europe and Northern Africa, *A. Donax*, is probably best known in this country for quickly producing picturesque scenic effect and for intercepting at once the view to unsightly objects. This species it is that furnishes most of the imported fishing rods and canes. That beautiful autumnal flowering reed, with its gorgeously feathery panicles, the pampas grass of lower South America, *Arundo Sellowiana*, is too well known to call for further praise. A species which could doubtless be successfully introduced into our Southern States is *Melocanna Bambusoides*, the berry-bearing bamboo of the Chittagong and other mountain regions of India. This bamboo grows to 70 or 80 feet, attains a circumference of

over a foot, is beautifully erect, thornless, grows well on dry land, and bears a large, fleshy, apple-like fruit, the seed of which is very pleasant eating, according to Masters and others.

While these and many other species are well worth cultivation in this country for their adaptability to decorative gardening, there are other species still more desirable, on account of their very great utility in building, furniture making, and fiber furnishing. Besides *A. Donax*, of Europe, which is an excellent small growth for rods and canes, *A. Sellowiana*, pampas grass, which is not only a decorative plant, but is also useful from the fact that the leaves furnish an excellent fiber for paper making, *B. Aspera*, remarkable for its size and strength, and *D. Strictus*, which is also a growth of great economic value, there are many other hardy species which are well worthy of introduction. *Arundo Ampelodesmes*, Southern Europe and Northern Africa, is possessed of tough flower stems and leaves readily available for tying and mat making. No doubt its fiber would be found to be of commercial value if cultivated with that in view. *A. Karka*, of Japan to India, furnishes the split stems from which the very durable Durma mats are made. *B. Spinosa*, Bengal, which grows to 100 feet in height, has much less width of central cavity than other species, and is therefore of greater technical value where strength is a desideratum. The best building bamboo in Bengal is generally conceded to be *B. Vulgaris*. This, when immersed in water for a time, becomes of a still firmer texture. *Gigantochloa Apus*, which grows in the Indian Archipelago up to 5,000 feet elevation, when young is so flexible and yet so strong as to be suitable for making ropes and cables that will resist great strain.

Even as food or forage plants some of the species of these remarkable plants are excellent. *B. Arundinacea*, the thorny bamboo of India, while it thrives best along river banks, will do very well in dry soil. Its seeds, as in the case of a few others of its congeners, are useful as food for fowls. *Dendrocalamus Hamiltoni*, from the foot hills of the Himalayas, which endures great cold as well as dry heat, furnishes an excellent esculent when the young shoots are boiled. This is also true of *Gigantochloa Verticillata*, *G. Apus*, and *Bambusa Bitung*. *M. Bambusoides*, already mentioned as among the decorative species, bears a seed in the pulpy fruit which is quite edible.

When the evident hardiness of certain species common to the high mountain regions is taken into consideration in connection with their technic worth, it seems surprising that so very little has been done toward introducing those species into our Southern States and even well northward. *Arundinaria Falcata*, *A. Japonica*, and *Dendrocalamus Strictus* have already been mentioned as moderately hardy species. *B. Vulgaris*, so excellent for building purposes, will resist night frosts. The Jurboota bamboo, of Nepal, occurs in the cold of altitudes up to 10,000 feet elevation. *Bambusa Flexuosa*, of China, a dwarf species, has, according to St. Hilaire, resisted a temperature of 8° F., while the Tham and Kaptur bamboos grow in the Himalayas at from 8,500 to 11,500 feet elevation, and, according to Major Madden, thrive along the margins of the perpetual glaciers. These species, then, should successfully withstand the winters from Southern Virginia down, and doubtless there are many other species like them in this respect.

Enough has been said here to indicate the entire feasibility of the introduction of certain bamboos into this country. The desirability of having either our agricultural department or some of our State boards of agriculture give the matter a share of their attention would seem to be unquestioned. What the possibilities of artificial selection and climatic influence may be can only be guessed. What they have been in the improvement of many of our leading textile and food plants it is fair to presume they would be in the case of some of these species of the bamboo tribe. Certainly the hope that they hold out for the utilization of swamp and other waste land in many of the regions where there is a lack of just such material as they furnish makes the attempt at their introduction a very desirable movement. Could such a species as *D. Strictus*, of India, which will endure any degree of dry heat, be introduced into certain portions of our far Southwest, where just such building material is greatly needed, its value would soon grow to be incalculable. There seems to be no reason why such an experiment should not be given a thorough trial.

Some of the uses to which bamboo is put where it is to be found in abundance illustrates how useful these plants might become if here introduced and if the inventive American mind were brought to bear upon them. Wallace, in his *Malay Archipelago*, thus speaks of the tribe and its uses:

"Almost all tropical countries produce bamboos, and wherever they are found in abundance the natives apply them to a variety of uses. Their strength, lightness, smoothness, straightness, roundness and hollowness, the facility with which they can be split, their many different sizes, the varying length of their joints, the ease with which they can be cut and with which holes can be made through them, their hardness outside, their freedom from any pronounced taste or smell, their great abundance, and the rapidity of their growth and increase, are all qualities which render them useful for a hundred different purposes, to serve which other materials would require much more labor and preparation. The bamboo is one of the most wonderful and most beautiful productions of the tropics, and one of nature's most valuable gifts to uncivilized man."

Why this most valuable gift should be left for uncivilized man alone to enjoy when there is such a vast area in this country where the most hardy species would doubtless thrive, does not seem plain. In all that South land of ours where the cost of lumber and the trouble of working it lead the poorer classes to resort to those hygienic abominations, the absorptive dirt floors, the bamboo would be a veritable godsend. A writer describing its adaptability to floor building thus speaks of its use in Borneo: "When well made this is a delightful floor to walk upon barefooted, the rounded surfaces of the bamboo being very smooth and agreeable to the feet, while at the same time affording a firm hold. . . . Here we at once find a use for bamboo which cannot be supplied so well by another material without a vast amount of labor, palms and other substitutes requiring much cutting and smoothing, and not being equally good when finished. . . . These, with constant rubbing of the feet and the smoke of years, become dark and polished, like walnut or oak, so that their real material can hardly be recognized."

By splittling the outer rind of the bamboo and shaving it thin excellent baskets, hen coops, bird cages, and fish traps can be made from a single joint, and in a surprisingly short time. For aqueducts and water vessels, by reason of its tastelessness, it is unsurpassed. Excellent cooking vessels in which rice, potatoes, and other vegetables can be boiled can be made from single joints; and sweet or sour preserves and salted meats are better kept in that way than in jars or bottles. The Dyaks of Sarawak make huge hubble-bubble pipes, sheaths for their long-blade dirks, and ornamental cases for their betel-chewing outfit. In bridge building, the construction of footpaths in dangerous localities in mountain regions, surfacing roads where quicksands or landslides are to be guarded against, and for temporary subsoil drainage their value is inestimable. The traveler in most of our primitive regions, South and West, is constantly brought face to face with the lack of bridges and safe footpaths over streams and in exposed positions. Were ready-made timbers at hand, as might be the case after the hardy bamboos had obtained a firm foothold there, a very inconsiderable expenditure of time and labor would obviate this great defect.

One of the most novel uses to which the bamboo is put is described by Wallace. He says: "One of the most striking uses to which bamboo is applied is to assist in climbing lofty trees by driving in pegs. . . . This method is constantly used in order to obtain wax, which is one of the most valuable products of the country" where this use of the bamboo is prevalent.

The method described by Wallace consists of making a series of rungs out of moderate sized bamboos, which are pointed at one end. A long, stout bamboo pole is stood up parallel to the tree to be climbed, and about 18 or 20 inches from it. At regular intervals holes are bored into the tree and the pointed end of the bamboo rung is driven into these and firmly wedged. The outer end of the rung is then securely bound to the bamboo pole, and thus step by step the native woodsman is enabled to build a substantial ladder, using the tree as one and the immovable side of the structure. I have myself used this form of ladder to enable me to reach the otherwise inaccessible tops of high-flowering trees that were attractive entomological treasures.

If the readers of the SCIENTIFIC AMERICAN who are so located that they could with reason hope to profit by the introduction of the various species of bamboos into their States will individually address to our Department of Agriculture, at Washington, inquiries relative to their introduction and requests for a supply of cuttings, no doubt the time will soon come when these very useful plants shall be numbered among the long list for which we have already to thank this efficient, active branch of our national government.

## SCARLET RUNNER BEANS.

IT is seldom advisable to sow or plant these in the open air earlier than the beginning of May. They may, however, with the view to accelerating the development of the plants, and thus securing an earlier production of pods, be sown in boxes or seed pans under glass in gentle warmth, and be finally planted out in a well enriched soil as soon as all danger from late frosts is over. Some sow or plant in trenches prepared similarly to those intended for celery. These trenches should not be less than 5 ft. or 6 ft. apart, and the plants require tall stakes to support them. In places, however, where ordinary stakes, such as are used for tall varieties of peas, are difficult to obtain poles may be substituted for them, even with advantage; they will be found to be in all respects equally suitable for the purpose, and with care will last for ten or more years. The poles should be some 8 ft. long, so that when let a sufficient depth into the soil to give stability they may stand some 6 ft. or 7 ft. high, and the same may be strengthened and kept in position by means of a horizontal rod fastened to each pole, which should be placed at a distance of 18 in. or 2 ft. apart. The plants will thus form, if desired, an archway (see illustration), an excellent screen or hedge to conceal any unsightly object; or they may be made to clothe the front of a rough wall or wooden fence of any kind, as with the assistance of a few strings they will readily adhere to them, and will at the same time furnish an abundant supply of delicious pods. Runner beans may also, though possibly less successfully, be grown in a dwarf form—that is, without the aid of stakes of any kind; and when this is attempted, it is necessary to frequently stop the strongest shoots. The surface of the soil should in such cases be well mulched with stable yard litter, so as to prevent the pods from becoming gritty by contact with the soil. Runner beans have an advantage over kidney beans, inasmuch as they bear continuously to the end of the season, or until the plants are cut down by autumnal frosts. Many, too, prefer the flavor of runners to that of the dwarf sorts. The scarlet runner may justly be considered an ornamental as well as a useful plant; and in addition to the common variety with its scarlet flowers, there are also white flowering sorts, as well as the variety known as the painted lady, or York and Lancaster, whose blooms are very pretty, and in color scarlet and white. There are also varieties producing very large pods, such as champion and giant white runners.

ARCH OF SCARLET RUNNER BEANS.

## THE FORESTS OF CALIFORNIA.

AT the last meeting of the American Forestry Congress, Hon. William Alvord, the president of that body, read a paper on this subject, from which we make the following extracts:

There is much about the sylva of California that is broadly distinctive, and not met with in any other part of the world. Some of the trees are larger and probably older than any found elsewhere, except perhaps among the eucalypts of Australasia, and they are not confined to small groups or belts, but are in great forests, some of which cover areas nearly as large as the whole of New England. There are millions of trees any one of which would yield enough lumber to build a good sized house. Twenty millions of acres of California are covered with magnificent forests; the remainder is sparsely wooded or wholly treeless.

The heavily timbered districts are confined to the Sierra Nevada mountains on the east, the mountainous regions in the northern half of the State, and what is known as the redwood belt, lying along and adjacent to the northwestern seacoast. The heavily timbered portion of the Sierra Nevada covers a territory five hundred miles long by seventy wide; the redwood belt and the timbered mountains at the north comprise nearly half as much more. The whole aggregates about 50,000 square miles of lumber-producing forests for the entire State, which contains 158,000 square miles.

There occur in other sections of California patches of lumber trees, the most important of these being in the Central Coast Range and in the San Bernardino and Kingston mountains; the product of the latter, situated in the desert regions of the southeast, is more valuable for fuel than for building material. The inferior growth consists mainly of several varieties of oak and pine, with some madrona, maple, walnut, alder and ash; the sycamore, willow and cottonwood grow along the watercourses and in other moist localities. The few trees that grow in the desert lands in the southeastern angle of the State are the mesquit, palm and the paloverde; the palms, of which there are several varieties, are almost worthless, being alike unfit for fuel or lumber, and they do not bear edible fruit nor furnish shade. These and the cactus are signs of aridity and barrenness.

The chain of mountains which skirts the easterly border of the State has an average height of about 8,000 feet, with long stretches much higher, some of the peaks attaining an altitude of 14,000 feet. The Piedmont country on the west, which attains an elevation of about 2,000 feet, and varies in breadth from fifteen to twenty-five miles, is covered with a sparse growth of scrubby oaks and pines; at the upper edge of the domain the more stately and valuable forest begins. While the foot hill oaks are of several kinds, the pines are mostly confined to a single variety, the Pinus sabiniana, called by Californians the digger or nut pine. The last name is given it on account of its edible nut, which constitutes one of the staples of subsistence of the Digger Indian. The nut pine, though little fit for lumber, makes a fuel nearly equal to hickory, and serves tolerably well for mine supports. Mingling with the oaks and pines are various dwarf trees, also much shrubbery, chiefly the ground oak, chemisal, buckeye and mazanita. These are worthless save for firewood, and they are being cleared off in many places, since the ground is found to be excellent for fruit trees, and many orchards are being set out here.

Leaving the red foot hills we enter the zone above, with its steeper acclivities and its wondrous wealth of woods. While nearly all that is valuable consists of conifers, there are oaks and many other deciduous trees in considerable numbers up to a height of 7,000 or 8,000 feet; also the nut pine up to 4,000 feet. This is the only conifer that does not thrive at a higher level.

While there is considerable shrubbery at these levels, the forests are so little obstructed with undergrowth that a wagon can be driven through them almost everywhere without much trouble. The woods lower down are still more open. The forests in this higher zone take in nearly the entire cone-bearing family, the pine, spruce, fir, cedar, juniper and cypress being represented, and they thrive in all latitudes and levels up to about 9,000 or 10,000 feet. Above this the trees dwindle in size and the wood deteriorates in quality. At about 12,000 feet of altitude vegetation ceases, the mountains above are of naked granite and mostly covered with snow all the year round. In the high and heavily timbered lands the conifers are represented by fourteen genera and fifty-two species, there being sixteen or more species of pines, all somewhat different from their Eastern congeners.

After leaving the foot hill country the first of these majestic trees encountered is the yellow pine (Pinus ponderosa), a tree of most noble presence. It is widely disseminated from central Oregon south to Mexico and laterally from the coast mountains east, across the Cascade and the Sierra Nevada ranges. In size and in value for lumber it ranks next to the sugar pine, which comes in a little higher up. In the mountains lying toward the sea, as also in the arid interior, the yellow pine is considerably smaller, but on the Sierra it attains a height of two hundred to three hundred feet and a diameter of ten to fifteen feet. It is among the best of our timber trees, the wood being soft yet firm and unusually heavy. A greater amount of lumber is made from it than from any other tree in the Sierras.

At an elevation of about 3,000 feet the sugar pine (Pinus lambertiana) begins to appear; its best development is reached at about 5,000 feet, and it extends the whole length of the big timber belt and covers a zone from twenty to thirty miles in width. Its grand colonnades run parallel with the general trend of the Sierra. In size it ranks next to the Sequoia gigantea, which in all other respects it excels. As a lumber tree it has no superior. The wood is nearly white, close grained and solid. No other timber works so easily, nor does any other crack or warp so little, for which good qualities it is in great demand for cabinet work and interior finish. It is largely used on the Pacific coast, and there is an export demand for it. The sugar made from the sap which exudes from it when cut or otherwise wounded is utilized for food by the Indians, but is not relished by the whites.

Being so valuable for lumber, the destruction of the sugar pine has been rapid, both the saw mill man and the shakemaker having until recently been allowed to depredate upon these trees at pleasure. As many of them do not split freely, it was the practice of the early shakemaker to fell one tree after another until he had found one that would rive to suit him. The rejected trunks were left to rot on the ground or to be consumed by the sweeping fires so common in these forests. Under this practice thousands of these trees were destroyed for no other purpose than to prove to the satisfaction of these vandals that they did not split freely. Through the enactment of laws sufficiently stringent to terrorize this class of woodsmen, our sugar pines and other valuable trees are now pretty well secured against such wanton and criminal waste.

The white silver fir, by reason of its great strength and durability, is much sought after for railway ties, bridge building and mine timbers. Some varieties of the spruce and hemlock also make a tough but rather coarse lumber. The home of these trees, which nearly equal the yellow pine, extends along the whole length of the Sierra, reaching laterally from 3,000 to 8,000 feet, the best being found about midway of this belt.

The incense cedar (Libocedrus decurrens) is another most useful and widely disseminated tree, its habitat reaching from southern Oregon to Mexico, and from 2,000 up to 6,000 feet above the sea level. In height it ranges from 100 to 150 feet, in diameter from three to six feet. The timber is adapted for a great variety of uses, being light, durable and strong; it is used in railway, ship and boat building. Having a straight grain and riving freely, great quantities of it are split into shakes and pickets, and formerly it was made into clapboards. The bark is thick and tough, and excellent for filling in boggy places in road building. This cedar is never found in groves, but is scattered through forests of the sugar pine, yellow pine, spruce, fir and hemlock, and is often called the white cedar of California.

## THE CHEAPEST NITROGEN AND PHOSPHATE.

### HOW ARE NITROGEN AND PHOSPHORIC ACID TO BE OBTAINED IN THE CHEAPEST WAY?

THE following is a translation, for which we are indebted to the London *Agricultural Gazette*, of a lecture on the above subject recently delivered by Prof. Paul Wagner, director of the Armstadt Experiment Station.

"In the manure market we find nitrogen in the form of Chile saltpeter, ammonia salts, blood meal, guano, meat meal, etc., and we must pay a mark and a half per kilo (about 18 cents per pound) for nitrogen in these fertilizing materials. This is dear. Is there no cheaper source? Does not chemistry teach us that four-fifths of the atmospheric air which surrounds us consists of nitrogen? Does not chemical analysis show us that humus soil and moor soil contain rich stores of it? That not less than 1, 2, or 3 pounds of nitrogen are contained in 100 pounds of dry moor substance? Certainly! we need not seek for richer sources of nitrogen. The atmospheric air offers us the nitrogen in immeasurable quantities, it offers it to us free of cost; but we must inquire, is it possible to make this rich source of nitrogen which is offered to us for nothing accessible to the plants we cultivate?

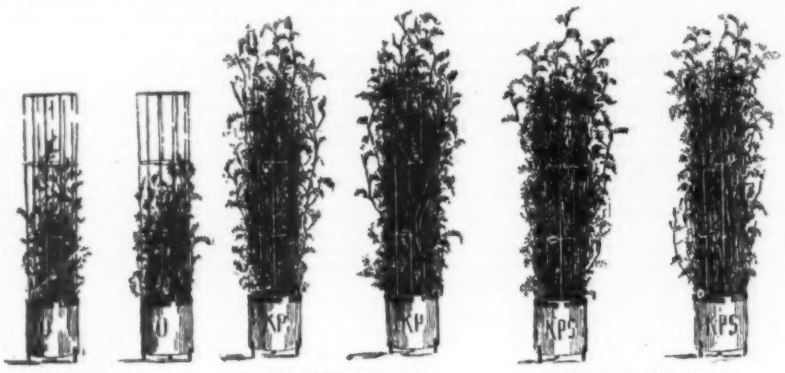
"To this question the researches of late years have given a definite answer of considerable value to practical agriculture, and indeed an answer which entirely contradicts previous statements. For many years we have been told that 'the free nitrogen of the atmosphere is not accessible to cultivated plants,' but this doctrine was false. The researches of Prof. Hellriegel, above all others, have shown us conclusively the incorrectness of it. Hellriegel has shown us that the free nitrogen of the atmospheric air is accessible, if not to all, yet to a well known and highly important class of cultivated plants.

"When leguminosæ are perishing for nitrogen, when vetches, peas, beans, clover, lucern, esparsette, serradella, lupins, etc., have consumed the soluble nitrogen present in the soil, then certain little microscopic fungi (so-called micro-organisms) of the soil attach themselves to the roots of these plants and cause little warty nodules to form upon them, and from this time forward the free nitrogen of the atmospheric air takes part in the nourishing processes of the above mentioned plants. The plants henceforth grow in a most luxuriant manner, and no longer languish for nitrogen.

"The results show us most distinctly that this nitrogen, for which we must pay the manure merchant so dearly, and of which the cultivated plants have to take up not less than from 100 to 200 or 300 kilos per hectare (89, 178 or 267 pounds per acre) in order to yield a maximum harvest, is offered to us by the atmospheric air, free of cost. Clover-like plants, all kinds of vetches, peas, beans, lupins, serradella, in short, all plants which bear a pod fruit, which belong to the so-called 'leguminosæ,' are endowed with the power of availing themselves of this inexpensive and rich store of nitrogen offered by the air.

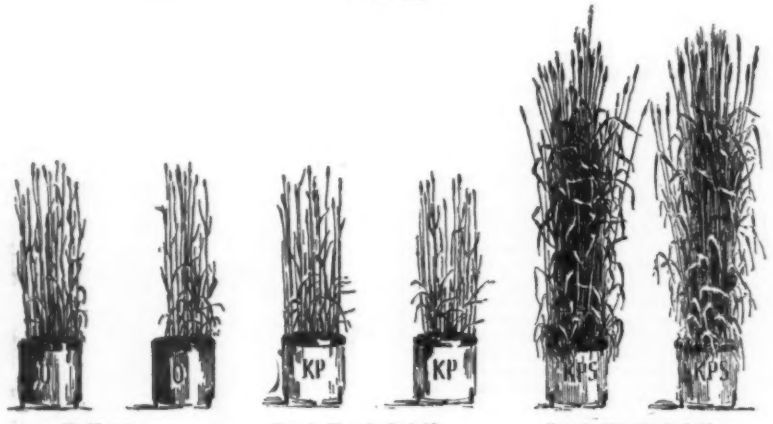
"How is it, then, that there are so many fields upon which clover, vetches, peas, etc., may be seen starving? How is it to be explained that the yield of meadows is frequently so exceptionally small, even when the clover, the peas, vetches, and all the numerous kinds of leguminosæ of meadow flora have at their disposal this vast quantity of nitrogen: this food which is so necessary to the profuse development of all cultivated plants?

"The answer to this question is not difficult; it is



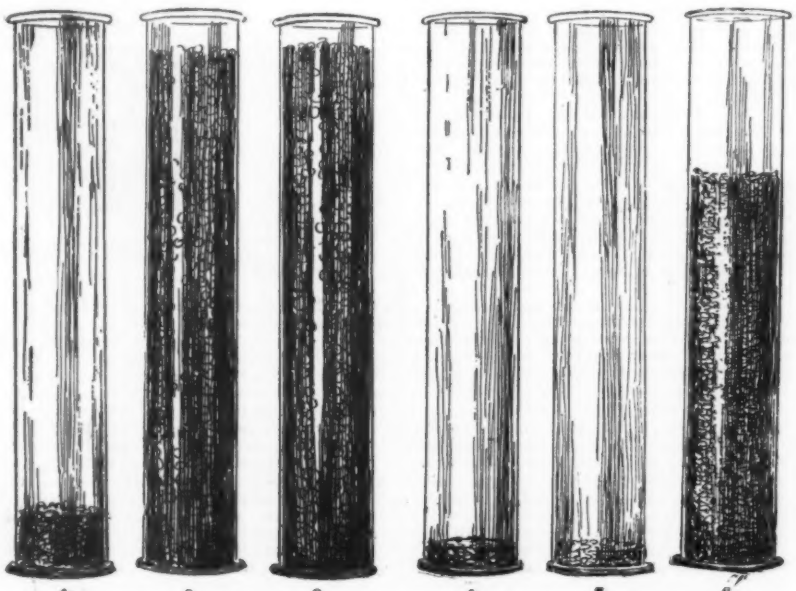

No Manure. Potash, Phosphoric Acid, *no* Nitrogen. Potash, Phosphoric Acid, *and* Nitrogen.

FIG. 1.—EXPERIMENTS WITH POTASH AND PHOSPHORIC ACID ON VETCHES.




No Manure. Potash, Phosphoric Acid, *no* Nitrogen. Potash, Phosphoric Acid, *and* Nitrogen.

FIG. 2.—EXPERIMENTS WITH POTASH AND PHOSPHORIC ACID ON WHEAT.




1. No Manure, 3·9 ounces. 2. Potash, Phosphoric Acid, *no* Nitrogen, 24·6 ounces. Increase, 21·7 ounces. 3. Potash, Phosphoric Acid, *and* Nitrogen, 25·4 ounces. Increase 22·5 ounces. 4. No Manure, 0·8 ounce. 5. Potash, Phosphoric Acid, *no* Nitrogen, ¾ ounce. 6. Potash, Phosphoric Acid, *and* Nitrogen, 16·3 ounces. Increase, 15·5 ounces.

(VETCHES.) FIG. 3.—YIELD OF THE CROP. (WHEAT.)

simply to the following effect: meadows, clover fields, pea and vetch fields, etc., do not hunger for nitrogen, but for phosphoric acid, and perhaps also for potash and lime. Nitrogen stands at their disposal in superfluous quantities, but they cannot take up and elaborate the nitrogen of the air as long as they are in want of phosphoric acid, potash and lime. If it is required to prove whether this statement is correct or not, the verification is very easy. Apply late in the autumn, or in the winter, about 15 centners (equal to 6 cwt. per acre) of Thomas' phosphate powder and 12 centners of kainit or 4 centners of potassium muriate (potassium chloride) per hectare (equal to 4 cwt. of kainit per acre, or 1⅓ cwt. of muriate of potash) to a poor meadow which is yielding only a very feeble crop of grass and wild herbage, etc., and you will find that quite a different vegetation will be developed, even in the first summer after this treatment has been introduced. Vetch-like and clover-like plants, which otherwise show themselves only on rich meadows, and which hitherto had not been observed upon the meadow in question, spring forth in vast quantities; they will develop well, and if in the following year the same manuring is repeated, then the poor and barren meadow will be converted into one thickly set with clovers. It will become a rich one, and will yield nourishing hay instead of the previously hard, herbaceous, inferior fodder.

"This is no imaginary experiment; it has been made by thousands of farmers during recent years with the best results, which have frequently been incredibly favorable, and, perhaps, all of the experimenters have already satisfied themselves sufficiently that an enormous increase in yield can be obtained by manuring meadows in the autumn and winter with potash and phosphoric acid."

This experiment is quoted because it shows in such an extremely feasible manner in which way and by which means we can bring ourselves to participate in the great advantages offered to us by the store of nitrogen in the atmospheric air. We manure leguminosæ with an abundant dressing of phosphoric acid, and, when necessary, with potash, for we know that the more rapidly plants satisfy themselves with potash and phosphoric acid so much the greater is the avidity with which they assimilate the atmospheric nitrogen and elaborate it into the harvest substance. We know well, and we experience daily anew, how a liberal dressing with phosphoric acid and potash will increase in an extraordinary manner the yield of peas and beans, of vetches and lupins, of clover fields and meadows.

Phosphoric acid and potash are the means which are placed at our disposal to render accessible to leguminous plants the cheapest of all supplies of nitrogen—the nitrogen of the atmospheric air. Prof. Wagner has had prepared photographic representations of some of his cultivations. Fig. 1 will illustrate experiments made with vetches. How very feebly the plants have grown without manuring, how luxuriantly, on the other hand, they have developed after a dressing with phosphate and potash, and how this dressing, without any addition of nitrogen, has already been sufficient to produce a maximum harvest. An addition of nitrogenous salts only gives rise to a quite unimportant increase in yield. A dressing with saltpeter and ammonia salts may therefore be regarded as a worthless extravagance on clover, lucern fields, etc. Nevertheless, Fig. 2 presents quite another picture.

On the *same soil* and under *exactly the same conditions* as employed when growing vetches, summer wheat was cultivated. Manuring with potash and phosphoric acid alone, without any addition of nitrogen, produced no effect in this case. It was only when nitrogenous salts were also employed that any action was evident.

In order to present the final results of this experiment in a tangible manner, Prof. Wagner has put the yields of grain obtained in glass cylinders, as shown in Fig. 3.

The cylinders contain:

No. 1.—82 grms. = to 2·9 oz. vetch corn
Obtained without manuring.
No. 2.—703 grms. = to 24·6 oz. of vetch corn
Obtained after potash and phosphoric acid.
No. 3.—724 grms. = to 25·4 oz. of vetch corn
Obtained after potash, phosphoric acid and nitrogen.
No. 4.—25 grms. = to 0·8 oz. of vetch corn
Obtained without manuring.
No. 5.—22 grms. = to ¾ oz. of vetch corn
Obtained after potash and phosphoric acid.
No. 6.—466 grms. = to 16·3 oz. of vetch corn
Obtained after potash, phosphoric acid and nitrogen.

It is therefore evident that phosphoric acid and potash are the materials by the use of which we can render this cheapest source of nitrogen accessible to leguminosæ (vetches, for example), namely, that store of nitrogen which is present in the atmospheric air, by the use of which we can, moreover, induce peas, vetches, lupins, serradella, esparsette, lucern, all kinds of clover, etc., to develop luxuriantly without any extra outlay for nitrogenous salts. The enormous advantages which are hereby presented to us are so very palpable that they do not need any further elucidation.

If, for the sake of example, we observe, as is frequently the case in practice, that a manuring of Thomas' phosphate powder and kainit, costing about 30 marks, can raise the yield of hay about 100 centners per hectare (or for an outlay of 13s. to 15s. per acre the yield can be raised by two tons of hay per acre), it is a result which needs absolutely no further recommendation.—*Rural New-Yorker.*

## SWEET POTATO CULTURE.

THERE seems to me to be a chance for many men who have small capital, and who are tired of working for others, to settle on a few acres, make a good living, and enjoy the health and independence so possible in country life.

There can be money made from the sale of plants as well as from the potatoes, and one who learns how to sprout them and establishes a good trade will find this a very profitable part of the business. I have been growing sweet potatoes for more than thirty years, and have found them a reliable and profitable crop, and think that I have learned some things of great value in that period. The only time I ever came near having a failure of the crop was when I planted on a clover sod, on a piece of mellow black land in fine condition, and I was greatly puzzled to know the cause of the failure; but, as I afterward met other growers who had had the same experience, I concluded that it was one of those cases of antipathy between plants which we often find, and I would not advise any one to try planting sweet potatoes on clover sod.

Every sweet potato grower should grow his own plants, not only because ordinarily they will cost much less than to buy them, but because he can be sure of the variety and of having good hardy plants, and can take them fresh from the bed when the weather is favorable, either late in the evening or on a cloudy or damp day. Sweet potatoes for seed usually cost $3 to $3.50 per barrel, and an average yield is not far from 10,000 plants; but I have grown considerably above this, and have rarely fallen to 5,000. The first thing to insure success in sprouting is manure *hot all through*. We bed the horses freely, and allow the manure to accumulate in a shed where some colts or horses run loose; and a week before I wish to make the bed, which in my latitude is about the middle of April, we fork this manure into a heap, shaking it loosely, so as to get the air well through it. It soon heats up thoroughly, and is then ready for the bed.

I make the bed flat, with two inch plank edges, and find that it requires not far from 100 square feet for a barrel of seed. Put the manure in ten inches deep when packed, and then three full inches of good soil on it to go under the potatoes, and as much more above them. It is well to put the soil all on at once, and the potatoes must not be put in until it all warms up. It will not do to let a heavy cold rain fall on the bed, and if there is a cold wind, as is often the case at this season of the year, it should be protected. I find the best plan is to cover the bed with straw a foot deep, and it will be more convenient if bound in bundles, and then put a roof of boards above with slope enough to carry off the water. Watch the bed, and if it does not warm up quickly enough, uncover it, and let the sunshine on it in the middle of the day. The bed will require no water as long as the straw is on it, but as soon as any plants show above the soil the straw must be taken off, and you must watch the bed closely, or the new plants will come up through the straw white as a potato sprout in a cellar. I leave the bed uncovered as much of the time as possible after the plants appear, as it gives hardy plants, but cover it if there is danger of frost, or if there are excessive cold rains, as, if the bed gets drenched so as to make the manure lose its heat, it often causes a black rot or fungus which greatly injures the plants.

The popular idea is that sweet potatoes must be grown on sandy land, and while I know it is easier to work, and possibly gives drier potatoes, yet I grow abundant crops of good quality on clay land. A friend of mine, who made a great success with this crop on a farm of eleven acres, found that his crop yielded much better, and the tubers were better shaped, if the land was plowed shallow and the hills or ridges made small, and after adopting this rule, his crop was largely increased in yield. The philosophy of it is that shallow plowing gives a ridge of good soil, that the tubers soon reach hard soil and stop their growth downward, and so grow thick instead of long, and in doing this loosen the hill so that air and heat are admitted. I do not plow the land at all now for this crop, but with a disk or spading harrow I work three and a half or four inches of the surface mellow, and make it fine by use of the plank drag or roller, and then with a one horse turning plow we throw two furrows together, so as to make sharp ridges three feet apart from center to center, and then set the plants two feet apart. This gives 7,200 plants to the acre, and one pound yield to the hill will make 120 bushels to the acre, and it is quite possible to grow nearly or quite two pounds to the plant.

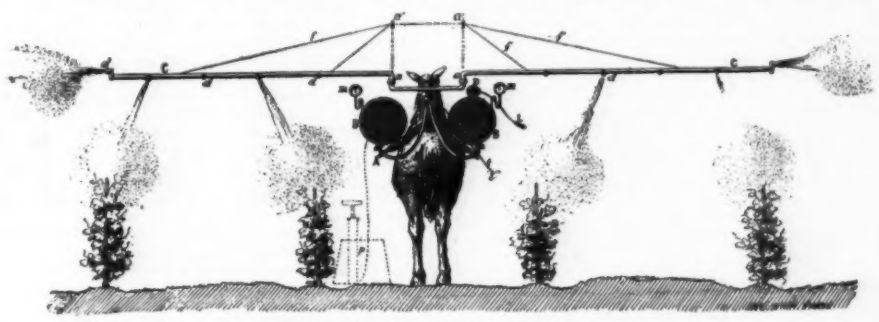
No other plants are more easily transplanted than the sweet potato. The bed should not be watered excessively after the plants grow so as to cover it, as it hardens them to allow the bed to get quite dry, but it should be well soaked a few hours before you begin taking up the plants. If the following directions are followed, the plants will not wilt at all, and from 95 to 98 per cent. of them will grow. 1. Puddle the roots thoroughly with a mixture of soil and fresh cow manure. This is much better than watering, and requires far less labor. The puddle must be made of such a consistency that it will adhere to the roots and coat them thoroughly, and the manure in it will give the plants a start, as the rootlets will find nourishment just when they most need it. 2. Set the plants deep and press the earth firmly about the roots, so that if you take a leaf between the thumb and finger and pull, the leaf will break rather than the roots give away. 3. After the plant is set, bring the soil up to it with both hands, so as to thoroughly protect the stem. Millions of plants are lost every year for want of this precaution, for plants grown in hotbeds and covered always have tender stems, and if these are exposed to the wind and sun, many of them will die; but attention to the three essential points I name—puddling, firming the earth about the roots, and protecting the stems with earth—will insure success in transplating.—*Waldo F. Brown, in Country Gentleman.*

## APPARATUS FOR SPRAYING GRAPEVINES.

WE represent herewith a spraying apparatus devised by Mr. F. Besnard. On each side of a pack saddle, A, there is a cylinder, B, of a capacity of 60 cubic decimeters, the lower part of which communicates with a large transverse pipe, C C, placed above the withers of the horse that carries the apparatus. This pipe is 6 meters in length, and is provided with a certain number of jets, *d*, the distance apart of which is regulated for rows of vines of 1, 1·2, 1·5 meters and 2 meters.

In the morning, at the beginning of work, the air in the reservoirs, B, is compressed to a pressure of from 1 to 1½ kilogrammes by means of an air pump, D, whose lever is seen at L. Then the lever is removed, and the apparatus is charged by forcing, through the aid of a pump, P, 30 liters of liquid into each reservoir, B. This operation raises the pressure to 3 kilogrammes, which is shown by the manometers, *m*. The apparatus is then ready for operation. The cock, *r*, is maneuvered from behind by a rod, *t*. A float valve automatically closes the communication as soon as the liquid is exhausted.

When empty, the apparatus weighs 80 kilogrammes, and from 110 to 150 when it is charged. The pipes, C, are jointed at *a a'*, and held by stretchers, *f f*, so that it is easy to make them describe a quarter circle in a horizontal plane, and to reduce, when necessary, the width of the machine to the proportions, B B.—*Les Inventions Nouvelles.*



APPARATUS FOR SPRAYING GRAPEVINES.

## THE SEWAGE FARMS OF BERLIN.

AT a recent meeting of the Institution of Civil Engineers, a paper was read on "The Sewage Farms of Berlin," by Mr. Herman Alfred Roechling, Assoc. M. Inst. C.E.

Berlin is situated in the sandy plains of North Germany on both sides of the River Spree, which empties itself into the Havel, at the town of Spandau, about 5½ miles below the city. The Havel is a tributary of the Elbe, and forms a succession of lakes immediately above and below the junction with the Spree, which are picturesque in places, and are a favorite holiday resort of the population. The flow of water in the Havel and in the Spree is very sluggish, and the latter river in periods of great drought discharges only about 400 cubic feet per second. The area of the city is about 24¼ square miles, and its population at the last census (December 1, 1890) was 1,578,794. The density varies from 220 to 25 persons per acre, each dwelling house (flat system) being inhabited by an average of 65 people. There are about 250 miles of streets, 80 miles of brick sewers, 285 miles of stoneware pipe sewers, and 55½ miles of pumping mains to the sewage farms. The water works were purchased (from an English company) by the city authorities in 1874, and the authorities also established their own gas works, as they could not come to terms with the Imperial Continental Gas Association. The city provides for its extraordinary expenditure by the issue of loans, the last loan, that of 1886, 2,500,000*l.*, was issued above par (101·18); this is an excellent indication of the credit it enjoys in the money market.

After the Franco-German war, Berlin became the German metropolis. Since then it has grown rapidly, and the changes it has undergone have been very marked. Whole districts have been cleared of the old insanitary houses, new streets have been formed, and others have been widened. Many new and elegant buildings have sprung up, the old abominably smelling street gutters, which were practically open sewage carriers, have disappeared, and under the sway of an intelligent and enterprising city council, which is, the sole municipal authority, Berlin has become one of the finest and best managed cities in the world.

It was originally intended to drain the city in the ordinary way by two main intercepting sewers, one on each side of the river, with one common pumping station, and to discharge the sewage, after some slight treatment, into the Spree. A scheme was prepared on these lines in 1861, but it was not accepted; and finally, after numerous experiments respecting the best mode of sewage disposal had been made, the city council decided to employ sewage irrigation, and Mr. Hoebrecht's new plan for the main drainage of the town was adopted in March, 1873. The works were commenced in August of the same year, and they have been in hand ever since. Under Mr. Hobrecht's scheme the whole area of the town is divided into twelve separate drainage areas, called "radial systems," which are entirely independent one of the other. They have each a pumping station from which the sewage is raised direct on to the farms, two drainage districts being in some cases united to one rising main. The area of these radial systems varies from about 674 acres to 2,117 acres, the total population in such of them as are entirely built over being about 200,000.

The authorities have purchased all of the land required for sewage farming; some of this land lies in the north and northeast, about six miles from the city,

and some in the south, about twelve miles distant from it. The total area of all the farms has now reached 18,790 acres, of which at present only 11,016 acres are under sewage treatment; the remainder is, however, being prepared for sewage farming, and the acreage of the farms is extended, as circumstances require. The subsoil on the farms is, generally speaking, sand, with a preponderance of sandy loam in places, especially on the northern farms, and is well suited for sewage irrigation. The land is practically level, with small eminences here and there. The sewage of about 112 persons is now treated on each acre of land.

The distribution of the sewage takes place by means of underground cast iron pipes, which start from the standpipes on the rising mains and terminate on the small summits, where the open earth carriers commence. The whole of the land that receives sewage has been especially prepared for irrigation by leveling and draining. The effluent from the farms is conveyed in open ditches into small streams, which empty into the River Spree, partly above, partly in the city, and partly below it.

The authorities employ a large number of "misdemeanants" in the work on the farms; these are men who have been sentenced for various minor offenses to undergo a period of confinement in the House of Correction; they are the loafers of the Berlin streets. From a philanthropic point of view, this course cannot be too highly commended, as it gives the men a chance to get back into regular habits and thus to redeem their characters.

The city has spent about 2,906,792*l.* in works of sewerage and 1,173,648*l.* in the sewage farms, and about 350 million tons of sewage have been utilized on the farms since the commencement of irrigation. Broadly speaking, the largest acreage in 1889-90 was under cereals, viz., 2,817 acres, then follow the grass plots with 1,785 acres, the roots and green vegetables take the third place with 1,013 acres, and oil-producing plants are cultivated only on 237 acres. There has been a very fair profit on the management of the farms since 1886, but of course the amount has not been sufficient to meet the payments for capital expenditure. The deficiency, however, is not a large one, as it has necessitated only an average annual rate of 0·89d. in the pound during the last five years, or a payment of 7·11d. per head of the population per annum. This is a remarkably small amount, and compares favorably with what has been paid in England for sewage utilization.

The degree of purification attained has been excellent, as on an average from 95 to 98 per cent. of the organic ammonia contained in the sewage has been abstracted on the farms. This is considerably above the figures quoted by the river pollution commissioners as the result of sewage farming in this country. The farms have had no ill effect upon the health of the population living on them, and the prejudice against them has almost died out, which is evidenced by the ever-increasing demand for sewage by adjacent farmers and landowners.

On the whole, Berlin is to be congratulated upon the cheap and efficient way in which it utilizes its sewage. Where other towns have failed it has succeeded, and that upon a scale at present without a parallel.

## ON PEROXIDE OF HYDROGEN: A PHYSICAL-MEDICAL RESEARCH.*

By BENJAMIN WARD RICHARDSON, M.D., F.R.S.

### PART I.—PHYSICAL AND PHYSIOLOGICAL.

IN the year 1856 I commenced the study of peroxide of hydrogen with the view of introducing it into medicine as an addition to our treasury of remedies. The history of this singular chemical body had at that time almost become forgotten, and no one, as far as I could learn, had ever taken it up in respect to medical research, although, as I afterward ascertained, a seat of learning at Haarlem did for some years offer a prize for such a research, which prize was withdrawn not long before my work was entered upon, simply because there had never been a competitor. The peroxide, when I commenced my investigations, was a chemical curiosity, so rare I could not obtain it in quantity, and was, therefore, obliged to set up the necessary apparatus for its manufacture in my own laboratory. After I found that there was an opening for the peroxide in medicine, I asked Mr. Lloyd Bullock to manufacture the solution on a sufficiently large scale, and he made two or three Winchester quarts of it; but as it did not fall in with his occupations at that time to continue the manufacture, it was undertaken by Mr. Robbins, of Oxford Street, who devoted the utmost care in carrying out all my wishes, and who has continued to manufacture the purest specimens of it for medical purposes up to the present time. Peroxide of hydrogen was discovered and described in the year 1818 by the illustrious French chemist, Baron Thenard.

#### *Origin of the Research.*

It may gratify a new generation of members of the medical fraternity if I very briefly relate what led me to use this peroxide in the first instance. It was in this way. I was working at ozone, and had been studying with the late Dr. Moffat, of Hawarden, the changes of disease in what he called "ozone periods." I made some hydrogen peroxide, and found that the oxygen condensed in it colored ozone test papers of starch and potassium iodide, a fact showing that this oxygen was more active than the oxygen of common air. It then occurred to me that the peroxide might be of service as a medicine if its action on the animal body and on the tissues were well investigated and defined. In those days we were inclined to believe that diabetes was due to the deficient oxidation of the tissues—a theory which an original observation of mine, namely, that dogs could be made to eliminate urine containing glucose, by subjecting them to an atmosphere of carbonic oxide, seemed to confirm. As a result of this line of thought I made an original investigation, the results of which I reported at length in a paper read to the Medical Society of London in 1860, describing the chemical, physiological, and therapeutic action of the substance, and explaining: (*a*) That the peroxide quickens oxidation, increases secretion, arterializes blood, and hastens the decomposition of decomposing animal tissues; (*b*) that in combination with blood it restores the power of contraction to muscles recently dead, and yet calms muscular irritability; (*c*) that it reduces muscular rigidity both before and after death; (*d*) that in instances of poisoning by narcotics and by the alkaloids it might, with advantage, be introduced into the blood by transfusion or injection; (*e*) that in tetanus it affords a most rational treatment, since tetanic rigidity is relaxed by its presence in muscle; (*f*) that in typhus, in which death occurs from what I designated *asphyxia commencing in the blood*, it might be employed with good effect as an oxygenator; (*g*) that it ought to prove useful both as an internal and external remedy in the treatment of cancer. I also described, in this paper, the best form of the peroxide for medical use, suggesting ten volume strength as the most certain and convenient for ordinary administration.

At the meeting of the same society on March 3, 1862, I made a second report on the medicinal use of the peroxide. I had by this time used it in two hundred and twenty-three cases of disease, including phthisis, diabetes, anæmia, sub-acute and chronic rheumatism, strumous enlargement of the cervical glands, mesenteric disease, pertussis, chronic bronchitis, chronic laryngitis, mitral disease, and dyspepsia. In epitome of results I drew the conclusions: (*a*) That in diabetes the peroxide reduced the specific gravity of the urine, while it rather increased the quantity; (*b*) that in chronic and sub-acute rheumatism it afforded relief; (*c*) that in valvular disease of the heart with pulmonary congestion it gave relief to the dyspnœa; (*d*) that in mesenteric disease and in jaundice it caused an improvement in the digestion; (*e*) that in pertussis its effect for good was very remarkable, since it cut short the paroxysms of cough, and seemed decidedly to shorten the period of the disease; (*f*) that in chronic bronchitis it lessened the dyspnœa, and rendered the expectorated matter less tenacious; (*g*) that in chronic laryngitis it gave pain on being swallowed, and did not appear to be useful; (*h*) that in anæmia it did not of itself render any service, but favored the good effect of iron; (*i*) that in the first stage of phthisis it caused improvement in the digestion, and in the later stages gave unquestionable and even wonderful relief to the breathlessness and oppression, acting, in fact, like an opiate without narcotism, and assisting oxidation.

In the discussion which followed upon the reading of this paper I was warmly supported in several points by Drs. Septimus Gibbon, Symes Thompson, and Gibb, all of whom had been prescribing the peroxide on the suggestions made in my previous paper of 1860. Dr. Gibb bore special testimony to its value in affording relief during the last stage of phthisis, for which I had recommended it in the case of a member of his own family. But the most important new observation I had to communicate to the society in 1862 was that in free and frequently repeated doses the peroxide could be made to produce a modified salivation, a fact which led to two suggestions; first, that in the use of mercurial and iodide preparations it was the chlorine or iodine in them which caused the ptyalism; secondly, that the peroxide would be a good substitute for mercury and the iodides in the treatment of syphilis.

It will be seen from these brief preliminary notes that my research had made a good start in 1862. From that time until now the work has never left my hands, and although it has been followed up intermittently, obstructed, now and then, for months by other labors, it has so accumulated that I have matter for a decent volume before me, which I hope soon to publish. From the pages of this intended treatise let me collect a few of the more important points for the present purpose.

It will be most convenient to divide what I have to relate into four heads: (1) Physical; (2) physiological; (3) practical or therapeutical; (4) pharmacological. But before entering on either point it will be necessary to devote a few moments to a description of some of the special qualities of the peroxide solution; otherwise I shall be talking an unknown language to those who are not conversant with certain primary facts, themselves unique in the history of chemical substances.

#### PHYSICAL.

Hydrogen peroxide must be looked upon as water containing, according to its strength, so many atmospheres of ozonized oxygen. It is an ozonized oxygen atmosphere in solution. It is not, however, a mere mixture, but a peculiar chemical compound. The oxygen can be made to accumulate, volume by volume, until the volume of water, say as much as would fill a pint measure, can rise to ten, twenty, thirty, and some say even a hundred and twenty pints of oxygen, before complete saturation is reached and a volatile body is formed. We hold, therefore, in a specimen of the peroxide, condensed oxygen combined either with the hydrogen of the water, or with the oxygen of the water, or with the elements HO acting as a radical. There is here not much difference, at first sight, from what is common in combinations where there is accumulation of one element on another; as, for example, in the combination of carbon with one equivalent of oxygen in carbon monoxide, and carbon with two equivalents of oxygen in carbon dioxide. But now comes a distinction. The combination of the added oxygen in hydrogen peroxide is stable in the presence of some substances, unstable and easily evolved in the presence of others. Some substances, inorganic or organic, when added to the solution are neutral; other substances, inorganic or organic, evolve the oxygen and are themselves unchanged; a third kind evolve the oxygen, and with that some of their own contained oxygen; a fourth kind absorb the oxygen into themselves.

We can illustrate this by experiment. Let seven flasks be equally charged with a ten volume solution of the peroxide. To flask *one* add a portion of peroxide of iron; the effect is neutral. To flask *two* add peroxide of platinum; there is brisk action, so that one can light a taper from the oxygen thrown off, but the platinum remains unchanged. To flask *three* add permanganate; there is very brisk action, and with the action evolution of oxygen from the manganese as well as from the solution. To flask *four* add arsenious acid; there is absorption of the oxygen by the arsenious compound. These are inorganic bodies; let us compare them with organic. Into flask *five* put albumen; the action is neutral. Into flask *six* put fibrine; there is brisk evolution. Into flask *seven* put red blood corpuscles; there is absorption. The analogy is perfect with one exception. I cannot find an organic substance that liberates the oxygen and at the same moment yields up its own oxygen. There may be such a body, but I have not yet seen it. Thenard, in a general way, had a wonderful knowledge of these distinctions, but he did not live to follow them completely out or to apply them. They are all-important to our medicinal labors, in pointing the way to success by the experimental instead of the empirical mode of questioning nature.

Of the solution itself, I may say that the more I have experimented with it the stronger have become my doubts as to its being a true chemical combination of oxygen with hydrogen, like that which obtains between oxygen and hydrogen in water. The taste of the solution is that of ozone, and is very persistent. The combination is very feeble, and very easily disturbed; the combined oxygen is extremely active; in fact, like ozone while in combination. I am therefore inclined to think that it is ozone chemically combined with water, and I would be inclined to call it aqueous ozone, or ozonized water.

#### PHYSIOLOGICAL.

In my researches I took up, one by one, the natural tissues of the body, in order to test them in the presence of the peroxide solution. In the end, for I have not space for details, the general fact which seemed fairly to have been elicited was that all structures of the body which have not become vitalized structures—albumen, for instance—have no power to displace the oxygen; neither have structures which have played their part and are actually dead, like nail and squamous cuticle, elastic tissue and mucus; while every structure that has become animalized and is passing through the stage of vital action does possess the power of displacement. Some substances, like red blood corpuscles, absorb the oxygen, as we have seen.

To put the matter now in the briefest possible form, living cell structure of every kind presented to the peroxide solution, if it does not absorb, liberates the oxygen, and seems to distinguish by that phenomenon organic structure that has become cellular organic and vital from that which is not yet cellular or organic, and from that which has passed from the organic and vitalized state to the inorganic and dead. Among organic substances those which approach nearest to what we, in our present state of knowledge, call "vital" show most activity of action, and those which have not lived, or which, having lived, are being cast off as dead, show least. To this latter there are one or two exceptions; the carbonic acid exhaled by the breath being the most notable, if we accept that gas as an organic substance.

Step by step in my progress in these researches I was led, almost imperceptibly, to another on which I have devoted much time, every inquiry being, by the nature of it, a slow process. The question opened was as follows: What effect will the oxygen liberated from a solution of the peroxide have on the organic substance that liberated it? This question also soon included two more, namely: How far will the effect be moderated (*a*) by pressure; (*b*) by temperature; (*c*) by pressure and temperature in combination?

#### *Action on Normal Surfaces.*

The action in the free state was very clear. Placed simply on open surfaces, so as to commingle with organic substances that will liberate it, the peroxide, by its liberated oxygen, produces decomposition, in turn, of the organic material. The process of the decomposition of the organic material is much expedited by an elevation of temperature, and this again is increased by pressure.

In all these researches I kept the following leading principle in mind. This substance, peroxide of hydrogen, is another or second atmosphere. It is a condensed liquid oxygen, part of the oxygen of which is easily liberated by mere contact with some substances belonging to the body. The breath liberates it; *ergo*, I might use my breath as a liberator. Here was ground for a new experiment. I used a mask after the manner of the one first constructed for anæsthesia. The mask had two openings into it. With one of these I connected a tube running to the long inlet tube of a Wolff's bottle; the other was attached to the exit tube of the same bottle, with an elastic bag intervening. Then I put on the mask so as to exclude myself entirely from the common air, and breathed forcibly through the solution. My breath caused evolution of oxygen, which was caught in the intercepting bag from which I breathed the gas and lived on it. By this means, even without removing the carbonic acid of the expired air, I could maintain life double the time it would be sustained in a negative medium, under water, for example. In this experiment I somewhat anticipated Fleuss in his diving apparatus, but followed St. Simon Sicard, who with condensed oxygen had done the same thing in his diving apparatus, although I did not know the fact, in 1854.

I next tried if the peroxide solution would serve for respiration, like oxygen, by immersing fishes in water from which the ordinary oxygen had been expelled, and to which neutral peroxide solution had been added. From these experiments I deduced that the peroxide had the power of sustaining the life of fishes, but not so perfectly as the oxygen present in common water.

In another line of research I sought to ascertain what would be the effect of introducing the solution into the alimentary canal, and into other cavities lined with mucous membrane and protected by mucous secretion. The result was, that if the cavities contained no foreign substance capable of liberating the oxygen, there was no action. Neither the bladder nor the uterus evolved the oxygen if they were in the natural state, but if they contained pus, or if their surfaces were broken in continuity, so that cellular tissue was exposed, then the solution, coming in contact with the purulent substance, or the cellular structure, was directly freed of its extra oxygen. If there were no cause leading to the liberation of the

* Continued from a research commenced in the year 1856.—*From the Asclepiad.*

oxygen while the fluid was in the mucous cavity, the fluid was either ejected or was absorbed into the circulation. If it were absorbed on entering into the circulation, the oxygen was set free and was taken up by the corpuscles unless it were in too large a quantity for immediate absorption, when it would accumulate in the chambers of the circulation, and destroy, as air does, after air is injected into a vein.

From the mucous surfaces I moved to the serous by injecting the fluid through the hypodermic needle into the closed peritoneal cavity. The animals operated upon were under chloroform, and it was observed that so soon as the fluid reached the peritoneal cavity the breathing became much quickened, but there was no sign whatever of distension or of escape of the gas. Very soon afterward the animals, still unconscious, died, and on opening their bodies immediately after death the cause of death was discovered. The solution injected had been absorbed into the inferior vena cava, and the blood in that vessel, in the right cavities of the heart, and in the pulmonary artery, was full of oxygen gas in the free state, by which the course of the blood over the lung was mechanically prevented.

In one of these experimental inquiries in 1868 I met with an experience I shall never forget. The animal under observation was a large strong cat, which had been subjected to the lethal action of chloroform. I allowed the animal to sleep to death, and after it was dead it occurred to me to test the action of the peroxide solution in the peritoneum; first, to see if the fluid would excite the diaphragm to action; and, secondly, to observe if it would be absorbed after death. I injected a fluid ounce of the solution of ten volume strength into the cavity through the hypodermic needle. To my surprise the breathing, which had ceased for several minutes, recommenced in full vigor, and in regular rhythm, but there was no return motion of the heart. Thereupon I opened the chest, and found the veins and right side of the heart filled with blood charged with loose oxygen. For a time I followed up this experiment under the hope that I might discover a simple application of the process for restoring life after death from chloroform in the human subject. At this time, however, my experimental researches had to cease. I shall revert to them as repeated at a later stage.

From the act of injecting the mucous and serous cavities with the peroxide solution, I proceeded to inject the solution, subcutaneously, into the cellular tissue. The effects were well marked; the fluid as soon as it was introduced into the cellular tissue gave up its oxygen. The gas diffused readily, producing some temporary emphysema, and was then absorbed into the circulation, giving rise to an elevation of temperature, and changing the color of the venous blood toward the arterial hue. No important local mischief accrued from the operation.

I made a bolder experiment. To an animal deep under chloroform I introduced the peroxide solution, directly, by injecting it through a fine needle into the lung structure itself, puncturing through an intercostal space. This caused an oxygen diffusion into the lung, during which the animal lived, in one instance for five minutes, with the respiration entirely cut off.

In an experiment on the muscles of an animal under chloroform I repeated what I had already done for removing muscular rigidity, but in a different way. Ammonia injected into a living muscle excites contraction tetanic in character. When this had been produced, the peroxide solution, warmed to the temperature of 100° F., was injected slowly, with the effect of producing relaxation. In a further trial the muscles of a narcotized animal were brought into contraction by a Faradic current, and in this state the muscles were injected with the solution at blood temperatures, with the effect of overcoming the resistance produced by the current, and of relaxing the muscles until the tension was increased.

*Action on Abnormal Surfaces.*

From the study of normal structures I passed to the study of some which are abnormal, tissues changed by disease, and compared the normal with the abnormal. I compared, for instance, ordinary mucous secretion with purulent secretion, and found that while the mucous secretion, in its simple form and freed of carbonic acid, was absolutely negative, purulent secretion, so long as it was free of decomposition, acted with great effect. I tested fresh translucent lymph by the side of pus. I took fresh clear lymph from a vaccine vesicle. The lymph caused no liberation of oxygen. When the vesicle had become purulent, I tested again, and found that the purulent matter liberated the gas actively. I let some purulent matter dry, in the usual way, on an ivory point, and saw that it still retained its activity because it had not decomposed. I let another portion, from the same source, pass into decomposition and then tested it; it failed in producing any effect.

Purulent matter possesses, then, strongly, the power of liberating oxygen from the peroxide, and probably the white corpuscles of the blood do the same. It may also be that the minute organisms called bacteria have the like power. In all cases the starting of the process is one of infinite subdivision of particular kinds of matter having a common property, and we may expect that in due time the common mode of their action as reducers of such compound bodies as peroxide of hydrogen will be discovered. This is one of the most important problems for solution in the whole range of medical science and art, because every condition of disease in its acute form, involving organic change of structure, depends primarily on the decomposition of oxides of the tissues, as I hope to demonstrate should my life be spared to complete the inquiries I am systematically carrying out.

In testing the action of the peroxide on natural organic structures which liberate oxygen from it, I observed, as related above, that the fluid oxygen causes, in some instances, decomposition of the organic matter. The same fact was observed with abnormal organic material like pus. When pus is placed for observation under the microscope, mixed with the neutral peroxide solution, the phenomena are most interesting. The pus corpuscles are, for a time, driven about as if they were alive. They move in all directions, assume ovoid shapes as they squeeze through masses that may obstruct their course, and after many variations of form and movement come to a standstill, like amorphous matter, dead, so to speak, and entirely disorganized. This effect of the peroxide in destroying pus cells led me very early in these researches to use the solution for the treatment of suppurating surfaces, and with great success, as will appear in a future chapter.

*(To be continued.)*

## A GIANT LIGHTHOUSE LENS—QUADRILATERAL ARRANGEMENT.*

By Mr. J. R. WIGHAM.

A YEAR ago in this room I read a short paper before this society entitled "Improvements in Lighthouse Lights," with an exhibition of the proposed new burners and their flames. On that occasion the lighthouse lights which I exhibited were explained and shown to be peculiarly applicable to a new system of lenticular arrangement "quadrilateral," which I briefly described, and mentioned the steps which had led up to its introduction, intimating that I hoped to have the pleasure of further referring to it on a future occasion. It is for that purpose that I have now the honor of addressing you.

The original lens designed for lighthouse illumination by Fresnel is 3 ft. 3 in. high by 2 ft. 7 in. wide, and it was constructed to transmit the light of an oil lamp, the flame of which was about 3½ in. in diameter by 3 in. high. A sample of this lens and lamp are on the table. This oil lamp originally had three concentric wicks; afterward another wick was added, and its illuminating power when at Howth Baily gas was first introduced as a lighthouse illuminant was 328 candles. The gas burners then introduced, and since adopted at Irish lighthouses, represented a very much higher illuminating power than this oil lamp, and their flames were of much greater dimensions. Each burner, as I explained in a paper read to this society at that time, could be used in five different sizes and degrees of power, according to the state of the weather. The smallest, which represented in size the Hincks oil lamp, had an illuminating power of 427 candles; the next size, 6 in. in diameter, 832 candles; the next, 8 in. in diameter, 1,253 candles; the next, 9½ in. in diameter, 2,408; and the largest, the flame of which was 11½ in. in diameter by about 8 in. high, had an illuminating power of close upon 3,000 candles.

This great illuminating power was capable of being augmented two, three, or four fold by the superposition of one, two, or three burners and tiers of lenses, called the biform, triform, and quadriform system; its effect for lighthouse illumination being capable of still further enhancement by the automatic extinction and reignition of the gas, forming what is termed the "group-flashing" system. The light from all these burners was originally transmitted through the Fresnel lens, having a focal distance of only 920 millimeters, and although the practical effect of the greater illuminating power of the gas lights in increasing the power of the beam from the lighthouses where they were employed was very marked, yet it was evident that a great portion of the light from the larger sizes of the gas burners was ex-focal, and did not produce a beam of anything like the power which the greater size of the luminary would produce if used in conjunction with lenses proportional to the dimensions of the burners. The great advantage of lighthouse illumination from the introduction of the gas system arose from two causes: (1) The greater illuminating power of the flame, which increased in proportion to the greater diameter of each burner; and (2) the diffusion of ex-focal light, which illuminated fog to an extent never before seen in lighthouse illumination.

To me it was a self-evident proposition that if lenses were constructed of suitable size and of suitable focal distance for the large-sized flames obtainable from gas, we would not only have an enormously increased focal light, but we might also have it with still greater diffusion of the useful ex-focal light to which I have referred. Twenty years ago, in this lecture theater, I gave expression to this opinion, and urged that lighthouse authorities would do well to have such lenses constructed, in order to do full justice to the gas system which had been inaugurated in Ireland. At the British Association in 1878, and again before that body in 1881, and at the Institute of Civil Engineers, London, in 1879, and the Royal Society of Arts, London, I brought under public notice the advantages which would result from the employment of such lenses. In the year 1885, a step in advance was taken by the Commissioners of Irish Lights on erecting at Mew Island Lighthouse, Belfast Lough, lenses 4 ft. high by 3 ft. 7 in. wide, but still with the 920 mm. focal distance.

After the South Foreland experiments had taken place, Messrs. Stevenson, the engineers of the Board of Northern Lighthouses, obtained the sanction of the Board of Trade to the purchase from the eminent firm of optical engineers, Messrs. Barbier & Co., of Paris, of a much larger lens for experimental purposes. This lens had a focal distance of 1,330 millimeters. Messrs. Stevenson called it a hyper-radiant lens. It was tested by them and the experts of Trinty House, and according to their report it was found, when used in conjunction with large burners, to have practically double the illuminating power of any lens previously made—a significant pronouncement of enormous importance.

Messrs. Stevenson's report gives their opinion that the use of such lenses would so much increase the light as to render unnecessary the application of the biform, triform, or quadriform arrangements. For this they gave no reason, but their idea evidently was that when by the use of this large lens they obtained as much light as would be given by the superposition of smaller lenses, they had accomplished all that was necessary. My ideas were not thus limited, nor did it strike me as desirable that the illuminating power of lighthouse lights should be restricted to the maximum advised by Messrs. Stevenson.

Having so long advocated the use of such lenses, and being so thoroughly convinced of the advantages which would result from their adoption, I lost no time, as soon as the pronouncement in their favor was made by Messrs. Stevenson and the Trinity House, in proposing to the commissioners of Irish Lights that, if they would adopt these lenses at Tory Island, instead of the lenses of the Mew Island type, which, according to their instructions, I was about to erect there, I would make without any charge to them the alterations to the lantern, etc., rendered necessary by this change. The commissioners, fully alive to the advantages of the new system, assented to this proposition, and thus became the first lighthouse authority practically to adopt it; and further, notwithstanding the opinion of Messrs. Stevenson that the light should be restricted to a single tier of lenses, and in the face of strong letters to them from the Board of Trade, urging that it was inexpedient to adopt any higher optical power with these lenses than biform, they determined, and adhered to their decision with a persistence worthy of all praise, to place these lenses at Tory Island in triform. The wisdom of this course has been abundantly justified by the most conclusive testimony from the commanders of great ocean steamers and others as to the advantages to navigation which have arisen from the establishment of that triform light.

While it was to me a matter of rejoicing that such large lenses should be made and placed at so important a lighthouse as Tory Island, and that the adoption there of 1,330 millimeter focal distance lenses was so successful, I still held that though a great advance had been made, it was not by any means all that could be accomplished. It seemed to me that there was no reason why still larger lenticular surfaces should not be used for lighthouse purposes with very great advantage, and I therefore propose that lenses having a focal distance of, say, 2 meters should be made, so that the whole of the light from a 12 in. gas burner might be utilized and transmitted to the mariner. I accordingly consulted with Messrs. Barbier, who entirely agreed with me as to the practical utility of such lenses and the feasibility of their construction. They had heard, as we all heard, that Lloyd's and great American steamship companies had expressed a desire that a particularly powerful light should be placed at the Old Head of Kinsale, and at my request they designed and made a lens suitable for such a purpose. It is now before you. It may well be called "the Giant" lens, for it is by far the largest lens ever made, and when it was erected in Messrs. Barbier's workshop in Paris it caused considerable sensation as a most remarkable work, and likely to effect a revolution in lighthouse illumination. I think you will agree with me that it is not only a splendid specimen of manufacturing skill, but a perfect work of art, reflecting the greatest possible credit upon Messrs. Barbier, its designers and constructors. The axial intensity of the lens is 800,000 candles.

The quadrilateral arrangement of which it forms a part is shown by the model on the table, which is made to one-tenth scale. You will observe that it is a model of the new apparatus in triform. Each face of the apparatus measures 10 ft. wide by 22 ft. 6 in. high, and the resultant beam is calculated to be equal to five million candles. You will observe that the apparatus is not of such size as could not be conveniently accommodated on a lantern of reasonable dimensions, such as might be placed in any lighthouse tower. The apparatus is only 14½ ft. in diameter, requiring a lantern 17½ ft. in diameter.

In triform the axial intensity is 2,400,000 candles, or two and a half times that of Tory Island. The duration of the flash would be six seconds, recurring every minute. With the new "intensity" burner, which is now lighter in the focus of the lens, the light would be five times the power of that of Tory Island. It is to be observed that in this calculation allowance has not been made for the fact that the lens, owing to its peculiar spherical form, will internally return to the flame the whole of the light reflected at the first refracting surface, so as to increase the amount of light emitted directly from the flame toward an opposite panel, which light in the case of the ordinary plane lens is wholly lost. If you examine this lens, which I hope you will do before the meeting breaks up, you will find every part of it to be most carefully ground, so as to refract or reflect the light from the large gas burner which I have placed in its focus. I am told that the mathematical calculations for this occupy many pages of close figures.

The great interest that attaches to this lens at the present time is that its appearing now is most opportune, because of the dissatisfaction of the French lighthouse authorities with the performance of the electric light as lighthouse illuminant. The electric light has been applied at some of their lighthouses for many years, and they had intended to apply it to many more of their lighthouses, but the complaints which have reached them have induced them to alter their determination. Hence the engineers of the French Lighthouse Department are naturally looking for a substitute, and it is for this reason that this new lens has excited so much interest in Paris.

We are, of course, all aware that the electric are light is by far the most intense artificial light which has ever been used for lighthouse purposes. I have experimented much with it. In clear weather its power is enormous. I have read the *Times* newspaper at Salthill by the electric beam directed from the Experiment House, at Howth Baily; but I found, as has since been also found in actual practice by seamen and others, that as the weather became foggy this enormous light diminished far more rapidly than did the light of an ordinary oil or gas lamp, and that these latter lights remained visible after the electric light had been entirely extinguished by the fog. The Shipmasters' Society, in a letter to the Trinity House, dated March 7, 1891, say:

"Many members of this society, in active service, frequently passing from the Thames to the sea, and *vice versa*, have often represented the poorness, sometimes invisibility, of electric lights during certain conditions of hazy atmosphere, at times when the oil lights of lightships, etc., and the gas lights of seaside towns have been comparatively bright and distinct." They continue: "Again, complaints have been made of the intense and blinding effects produced on navigators by electric lights such as the South Foreland on vessels in its immediate vicinity."

The reports from the United States of America are also unfavorable to the electric light as a lighthouse illuminant, and show that its use has been actually given up in the States. The New York *Electrical Review* says that "the lighthouse officials have given up

* Read before the Royal Dublin Society, April 20.

the idea of using electric lights in lighthouses. The electric light which was established for the purpose of testing its adaptability to the service proved so unsatisfactory to navigators, and brought such earnest protests from shippers, that it was abandoned." Thus it would seem that the electric light as a lighthouse illuminant is unsatisfactory to British seamen, that in France its progress has been arrested, and that in the United States of America its use has been absolutely abandoned.

The lens at which we are working may be regarded as the furthest development on a practical scale of the principle of quantity or volume, in contradistinction to intensity in the light used for lighthouse purposes. The electric light—the highest example of intensity—has put forth its greatest effort at St. Catherine's Point, Isle of Wight; its six or seven millions of candles have there full play, with what effect the nautical portion of the community in view of the stranding of the Eider, and the correspondence which has arisen thereupon, are now seriously considering. This new lens and its large gas burner will enable the advocates of volume to show what they can do. The maritime public are watching the contest with much interest, human lives are involved in the issue, and although some may say that victory is already on the side of the larger but less intense illuminant, and that the electric light has been tried and found wanting, the other side has not yet been allowed to show what the full power of gas and large lenses can do to fill the place which it was fondly hoped the electric light would occupy.

The commissioners of Irish lights have decided to allow this great lens to be erected in the Experiment House at Howth Baily for the purpose of practical trial, and we may hope that with that wisdom which they have shown on former occasions, they will again take the lead in this matter, and give to the mariner the full benefit of this latest development of lighthouse illumination. The experiment will be one of much interest, and any of you who live in the neighborhood of Kingstown will have a chance of seeing it. In fine weather, of course, the large lens will completely outshine its powerful neighbor, the ordinary light of the Baily lighthouse; and should foggy weather intervene during the experiments it will, I think, be found that long after the Baily light, even at its highest fog power, is lost to view, the light from our giant lens will still assert itself.

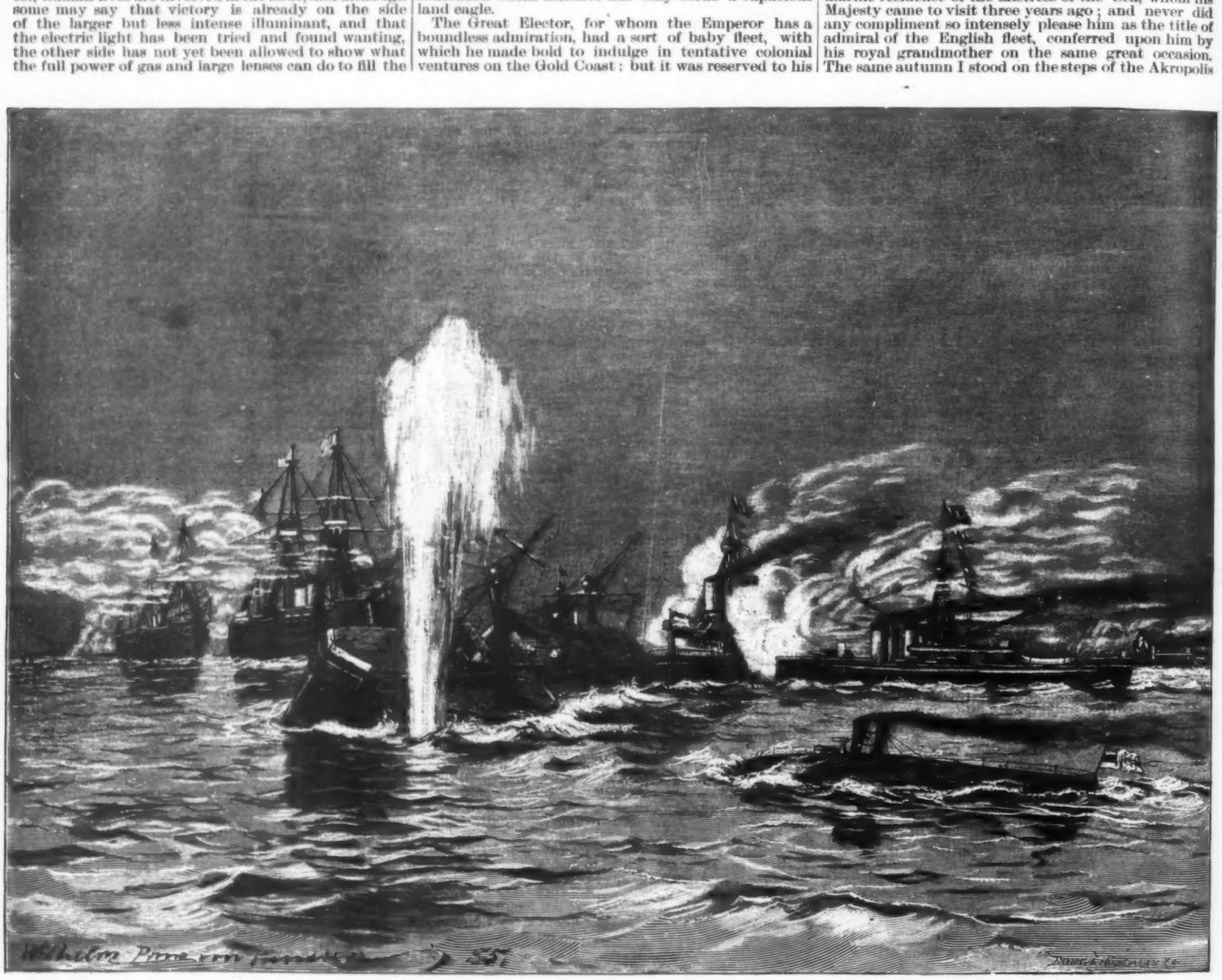
## THE GERMAN EMPEROR AND HIS NAVY.

By CHARLES LOWE.

ONE of the most interesting objects in the Art Gallery of the late German Exhibition at Earl's Court was the drawing of an old three-decker, from the hand of the present German Emperor when Prince William of Prussia. This was the war vessel of the past, and I have seen a sketch of what his Majesty conceives will be the battle-ship of the future—a misshapen monster, bearing a strong resemblance to a huge floating battery or railway ferry boat, such as may be seen plying in Danish and other island-dotted waters. This latter sketch, a brilliant enough thing in its way, the Emperor dashed off on his blotting pad when conversing with an American visitor, who begged and got leave to include it in his collection of artistic curios. Half way between the past and the future of naval warfare as thus portrayed by the Emperor is an "Engagement between ironclads and torpedo boats" (given with this article), from a drawing in 1885 by Prince William, which he dedicated to his sailor brother, Prince Henry. Critics will have their own opinion as to the mere technical merits of these performances—though, in forming their estimate, they had better remember that the artistic instincts which Prince William inherited from his highly gifted mother were carefully trained by Professor von Angeli, of Vienna, and Herr Saltzmann, the marine painter, of Berlin. But what I wish to point out is the interesting and significant fact that the Emperor's brush and pencil have been applied by preference to naval subjects. He is the first of his race, so to speak, who has taken seriously to the water, so that a duck might now fittingly enough be added to the scutcheon which hitherto has only borne a rapacious land eagle.

The Great Elector, for whom the Emperor has a boundless admiration, had a sort of baby fleet, with which he made bold to indulge in tentative colonial ventures on the Gold Coast: but it was reserved to his ambitious descendant, Kaiser William II., to scour the seas in search of ownerless and unattached lands, whereof to make a new Germany *outre mer*. Of all the phenomena connected with the regeneration of Germany none is more striking or momentous than the creation of its fleet, which is now the second strongest on the Continent of Europe, and all in little more than a score of busy years. While solicitous enough about the naval fortunes of the fatherland, the old Emperor was essentially a soldier in his preferences and pursuits; but his grandson, while equally ardent in his devotion to the army, has a very large corner in his heart for the fighting force of Germany by sea; and he had not been long on the throne before he organized—in the historic region of the redoubts of Duppel—combined land and sea maneuvers on a scale unprecedented even in England. He is the child of his time, which is one of naval and transmarine enterprise, and he grew up, so to speak, with the growth of the imperial fleet, being fascinated with the novelty of this instrument for protecting the fatherland at home and expanding it abroad. From his mother he inhaled the inspiring story of England's greatness, and he was struck with the strong desire to emulate her methods of exerting and acquiring power.

When a boy at Potsdam he was fond of reading naval novels—especially those of Captain Marryat—and nothing delighted him more than to have an occasional cruise among the loch-like arms of the Havel on board a miniature sailing frigate of the old type, which was once sent as a present from the royal family in England. He was also a passionate rower, and a very strong one, too, albeit restricted to the use of one arm; and when the 'Varsity race fails to Oxford, which he once visited as Prince William, he never fails to send a warm congratulatory telegram to the winning crew. Though, like Lord Nelson, not a particularly good sailor, the Emperor's enthusiasm for the sea is superior to all its horrors; and even its terrors gave a fresh zest to his second return journey from Russia, when the Hohenzollern was caught in a tremendous storm and all but wrecked. Every summer finds him cruising about among the fiords of Norway, where his own pencil and brush are ever as busy as those of his invariable companion, Herr Saltzmann, with the incidents of his trips; and now nothing will content his Majesty but that, through the purchase of the Meteor, erstwhile the quick-sailing Thistle yacht, he shall acquire a status other than that accorded him by his sovereign rank among the autumn society of Cowes. Never did the Emperor enjoy any spectacle half so much as he did that of the two long lines of England's iron-ribbed bulldogs, as they lay stretched along the brine of the Solent, in front of the marine residence of the Mistress of the Sea, whom his Majesty came to visit three years ago; and never did any compliment so intensely please him as the title of admiral of the English fleet, conferred upon him by his royal grandmother on the same great occasion. The same autumn I stood on the steps of the Akropolis watching the German fleet as it steamed up the Saronic Gulf with the Emperor, on the occasion of his visit to Athens, and there, streaming from the main of the Kaiser, above the standard of the Hohenzollerns, was the ensign of England, at once the latest and the proudest designation of fleet admiral the Emperor William.



A FIGHT BETWEEN TORPEDO BOATS AND IRONCLADS.—FROM A DRAWING BY THE EMPEROR OF GERMANY.

Can it, therefore, be wondered at that, with his heart so given to the sea and its ships, the head of the Emperor should be so full of naval imagery, and that some of the boldest metaphors which have graced his after-dinner speeches should have been borrowed from the German Ocean and the Baltic? Who has forgotten the oration which his Majesty delivered at Bremen on board the North German Lloyd's steamer Fulda? "As a friend of maritime affairs," he said, "I follow the phenomena of nature. When I sailed the Baltic with a squadron for the first time, the question of a change of course arose. The change was made; but the ships were separated in the fog in consequence. Suddenly the German flag emerged from the mist high above the clouds—a surprising sight which filled all of us with admiration. Later, the whole squadron, accurately steering its new course, emerged after the fog had blown off. This seemed to me a sign. Whatever dark hours may come to our fatherland, we shall reach our goal by dint of pushing forward, according to the grand watchword, 'We Germans fear God, and nothing else in the world.'" Similarly, it was in the spirit pervading this

effusion that, when christening a new corvette at Wilhelmshaven (and the Emperor is never happier than when launching ironclads) he glorified the deeds of his sailors who were overwhelmed by the Samoan disaster, comparing their fate to that of the Spanish Armada, and saying: "And now, gentlemen and comrades, may the beautiful example which those brave men set us ever shine before us, stirring us up to emulation, and may the spirit of devotion, discipline and courageous perseverance unto death, which has always distinguished my navy, ever continue to be present in it, in which sense I raise my glass and toast 'the German navy, especially its brave officers.' Hurrah!"

And it was again in naval imagery that the Emperor expressed himself when he suddenly dropped his pilot (Bismarck), and wrote: "The post of officer of watch on the Ship of State has fallen to my lot; but her course remains the same. So now full steam ahead!" Among all the multitudinous portraits of himself which the Emperor has caused to be executed, perhaps the most striking is that of his Majesty, in his naval uniform, standing on the bridge of a war vessel, with a telescope under his arm, and a proud defiant look upon his face. Certainly Lord Nelson could never have looked half so haughty and invincible after the battle of Copenhagen or the Nile; but then the German Kaiser belongs to that class of resolute and resourceful men who, at a moment's notice, would as lightly undertake to perform a surgical operation or sink a fleet. "*In utrumque paratus*" is his bold and versatile motto.—*The London Graphic.*

## THE WORK OF REMOVING THE ROCKS AT THE IRON GATES ON THE RIVER DANUBE.

*Drilling Methods.*—In these methods, mine holes, spaced about 5 ft. apart, are drilled to the full depth of the rocky stratum to be removed, and all these mines, properly charged with explosive material, are blown up simultaneously.

The systems of rock drills are numerous, and yet but four of them are practical. Up to the present, there have been but a very small number of apparatus (not more than three to our knowledge) that are so combined as to present a true floating, working platform from which all the operations of drilling, charging and exploding can be performed mechanically without the aid of divers. Of these, the oldest is the one that was employed by the English for removing rocks in the Clyde, near Glasgow. The rock drills, which were rotary, were provided with crowns with inset diamonds. They were established along the side of a lighter, and were suspended freely by the head along with their electric or steam (Brotherwood) motor. In this way, the drills penetrated the rock nearly vertically, and their advance was produced by the weight of the motor that they supported. It is this system that gave rise to the two apparatus (one American and the other French) that have been adopted for the removal of the rocks at the Iron Gates on the Danube.

The American apparatus differs from the English only in the substitution of percussion drills of the Ingersoll-Sergeant type for rotary ones. These drills, which have done most brilliant service in the United States, in mining and tunneling work and especially in the submarine work at Hell Gate, need no further commendation, but we know that their power is somewhat reduced by the violence of the currents and the slight stability of the boat that carries them. Fig. 1 represents the American apparatus in operation. It is provided with three Ingersoll-Sergeant percussion drills actuated directly by steam.

In the French apparatus less attention has been paid to the drill itself than to general installations that permit of obtaining at will, and in a very short time, an easily maneuvered floating apparatus or an absolutely stationary platform.

Fig. 2 represents the French apparatus installed upon the Danube, and Fig. 3 gives a perspective view of it seen closer by. In our engraving may be plainly seen the boats, the piles, the drill carriers and the windlasses. The two cabins seen at the right and left are designed, one of them, for the operations of electric blasting, and the other for the storage of supplies.

The floating platform consists of two juxtaposed flatboats upon the interior sides of which rolls the carrier of the drills, which are thus capable of piercing the whole area comprised between the two flatboats. In measure as the mine holes of the same transverse row are simultaneously drilled they are charged, and the mechanically formed circuits of excitation are attached to a commutator tablet arranged near the electric machine.

After all the above mentioned area has been mined, the windlasses are maneuvered and the flatboats are moved to a distance of about 50 yards from the mine holes. Various bobbins in communication with the latter unwind, and it only suffices to set the electric machine in motion and to make it pass from the short to the general circuit to effect the instantaneous explosion of all the mines.

The two flatboats, firmly connected, are provided with four very strong piles which serve to convert the floating apparatus into a temporary stockade. To this effect, the piles are lowered to the bottom, and through the aid of powerful windlasses the flatboats are lifted out of the water. Under such conditions, the current has no longer any action upon the platform of the drills.

One or other of these apparatus, probably a combination of both, is destined to give good results, but we are not able to assert that they will be applicable to all the points of operation on the Danube, and especially in times of freshets or low water. It will remain, besides, to solve the question of dredging, which is hardly any easier to perform under conditions that are so disadvantageous, and which has not yet been experimented upon. It must not be forgotten, in fact, that all the difficulties are accumulated at certain points of these fields of operations. The bed is very irregular and passes abruptly from depths of 16 in. to unfathomable holes, and to abysses 180 ft. in depth. This is why it was not possible to think of the rational method employed by Mr. Hersent in the work of removing the rock in the port of Rochelle. This process consists in establishing the drills on the bottom to be excavated, which is rendered dry through the aid of air compressed in a tight caisson. The workmen can then select the spot for the mine hole, estimate the depth to be perforated, and the direction and intensity of the charge, and, in a word, they need not work like blind men as in the preceding systems. As soon as the explosion has occurred they remove the debris under very much better conditions than does a mechanical device which scrapes at hazard.

Neither was it possible to apply another method of work which gave excellent results in the submarine operations at Hell Gate, N. Y. In this work a series of contiguous galleries was excavated under the rocky bed to be deepened, by means of Ingersoll-Sergeant drills of the tunnel type.

After these catacombs, so to speak, had been formed, large quantities of explosives were introduced and afterward ignited by means of an electric discharge. The pillars then fell in, carrying with them the general roof, whose accumulated debris did not rise above the level anticipated. This process is applicable only to a compact rock and to a stratum of pretty uniform character. The shores, too, must lend themselves to the priming of the galleries, both by their proximity and their topographical configuration.

The problem, then, is not easy to solve, and there is

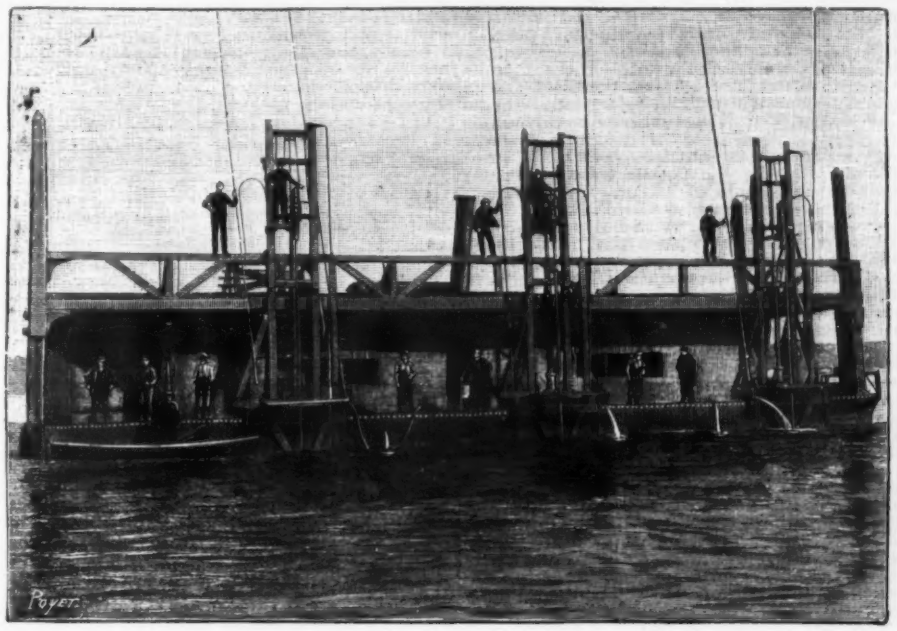


FIG. 1.—AMERICAN DRILLING APPARATUS ON THE DANUBE.

FIG. 2.—FRENCH DRILLING APPARATUS INSTALLED AT KOZLA, HUNGARY.

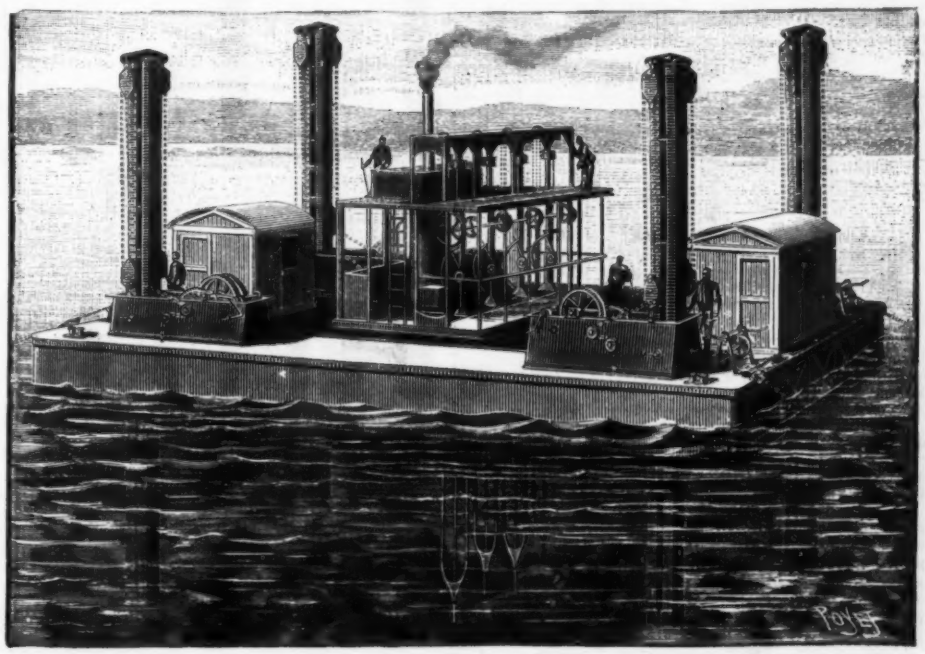


FIG. 3.—DETAILS OF THE FRENCH APPARATUS.

reason to ask whether the Lauer method, modified, would not give excellent results. It would be a question of combining this method with the drilling method so as to greatly increase the effects of it by forming a ten inch mine hole and charging it with an extra high explosive.

However this may be, the information obtained from the operations at the Iron Gates will be most interesting, for they will necessitate a *materiel* and improved processes that will constitute a very important progress in this special branch of public works.

After the work is finished, the flotilla of the Danube will be able to sail at all times from the Black Sea to Vienna and beyond, and thus in a large measure develop the prosperity of all the countries bordering this king of European rivers or its different affluents. These regions are numerous and important, and comprise Bosnia, Croatia, Servia, Hungary, Bulgaria, Roumania and Bessarabia.

As has been well remarked by Mr. E. Reclus, in his New Universal Geography, it is to be regretted (and this will be true more than ever) that this natural waterway of such importance debouches at the eastern extremity of Europe. What would not its destiny have been if the Danube had had its mouth situated at the very heart of the Mediterranean! This regret would have been condemned to remain in a Platonic state had it not been for a new conquest of the engineer's art; we refer to the ship railway in course of construction in Canada—a work whose inauguration will certainly be celebrated during the course of this year. We shall soon see ships of 3,000 tons come out of the water all loaded and traverse the continents to again enter their element at any distance desired and however broken be the country that separates the two navigable ways. The most incredulous will then comprehend all the consequences of this new mode of carriage upon the direction of the future commercial currents, and, to cite but one example, the *desideratum* of Mr. Reclus may be accomplished by putting the Save, and consequently the Danube, in correspondence, if not in communication with the port of Fiume upon the Adriatic, according to the project conceived by one of our compatriots, the promoter of the ship railway.—*La Nature.*

## A HAND TELESCOPE FOR STADIA WORK.*

By ROBERT H. RICHARDS.

IF one holds up a prism or wedge of glass with narrow angle, say 1° to 2°, and compares the transmitted image with the image seen above or below the prism, the former will be found to be thrown to one side by an amount varying with the angle of the wedge. Speaking of the two rays as the direct ray and the bent ray, we may say that when the bisecting plane of the prism is at right angles to the line of sight, the angle between the direct ray and the bent ray will be constant for any given prism.

If now we place a prism or wedge of glass in such a position that it half covers the objective of a telescope, we shall obtain on looking through it two images of every object seen—one image by the direct ray, which comes through the uncovered half of the objective, the other which comes through the prism, and is the image by the bent ray. The angle of divergence of these two rays will be constant and unalterable, whether the telescope is directed to a near object, with its eye piece at increased distance from its objective, or upon a distant object, with eye piece nearer to the objective. That is to say, if the "throw" or apparent dislocation of the images is one foot in one hundred feet, it will be two feet in two hundred, ten feet in a thousand, and so on.

The usual form of stadia telescope has at the focal point of the objective two spider lines, placed at a definite distance apart, and intended, let us say, to represent a throw of foot in one hundred feet. But as the distance between lines remains the same, while the distance from the objective to the webs differs with every variation in the distance of observed objects, it follows that the angle between the lines of sight which these two spider lines define cannot be constant, but must vary with every increase or decrease of distance between the instrument and the object viewed.

If in Fig. 1 we represent three positions of the

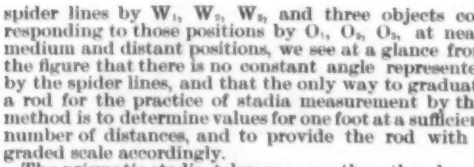


Fig. 1.

spider lines by $W_1$, $W_2$, $W_3$, and three objects corresponding to those positions by $O_1$, $O_2$, $O_3$, at near, medium and distant positions, we see at a glance from the figure that there is no constant angle represented by the spider lines, and that the only way to graduate a rod for the practice of stadia measurement by this method is to determine values for one foot at a sufficient number of distances, and to provide the rod with a graded scale accordingly.

The prismatic stadia telescope, on the other hand, has a constant angle for all distances and all focal lengths; and when the factor has once been obtained it may be used to graduate a rod with uniform scale from end to end.

Again, the usual stadia instrument involves two points of observation. The operator adjusts the lower spider line on the zero of the rod and then observes the reading of the upper line on the rod. There are, therefore, two personal equations in the operation of taking readings. With the prismatic stadia telescope, on the other hand, both observations are made at once, just as the sailor, in taking the altitude of the sun at sea, brings the sun's image to the horizon and observes the contact. Only one personal equation is thus involved.

The spider line stadia telescope cannot be used by simply holding it in the hand, but requires a firm support; for, if it were used in the hand, the first line would wander from the zero on the rod before the reading of the second line had been taken. The prismatic stadia telescope, on the contrary, can be used in the hand, just as a sextant is. Nevertheless, as the readings to be made with it are much finer than those of the sextant, a support will be preferred for most purposes.

The one great advantage of the spider line over the prismatic telescope is that it uses the full light of the whole objective at all times, while the prismatic has only half light. This objection to the latter is completely removed when the spacing target rod is used; and it is fairly well met by the employment of self-reading rods, to which reference will be made below.

In adapting the prismatic stadia telescope to the needs of the surveyor, several important matters have to be determined, relating to the prism and also to the telescope and the rod.

In my experiments I have combined a telescope of 30 diameters magnifying power with a prism of 1 ft.

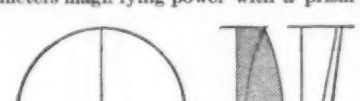


Fig. 2.

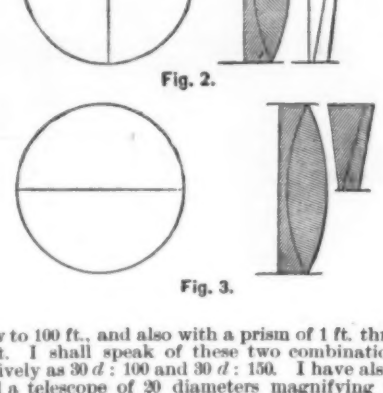


Fig. 3.

throw to 100 ft., and also with a prism of 1 ft. throw to 150 ft. I shall speak of these two combinations respectively as 30 $d$ : 100 and 30 $d$ : 150. I have also combined a telescope of 20 diameters magnifying power with three prisms, throwing respectively 1 ft. in 50 ft., 1 ft. in 100 ft., and 1 ft. in 250 ft., and I shall speak of these combinations as 20 $d$ : 50, 20 $d$ : 100 and 20 $d$ : 150. Finally, I have combined a telescope of 10 diameters magnifying power with prisms of 1 ft. to 50 and 1 ft. to 100, and I shall call these combinations 10 $d$ : 50 and 10 $d$ : 100.

The first fact I encountered in these experiments was that 10 $d$ : 50 and 10 $d$ : 100 can be used with uncorrected prisms, since the amount of color does not seriously injure the observation, while no prism not thoroughly achromatic was found satisfactory for either the 20 $d$ or the 30 $d$ telescope.

Fig. 2 represents what appears to me to be the rational and proper mode of combining the prism and the objective; while Fig. 3 shows an improper combination. In Fig. 2 the bent rays are exact counterpart of the direct rays, while in the adjustment of Fig. 3 this is not the case.

*Choice of a Prism.*—For hand use a wide prism is preferred, say 1 ft. displacement in 50 ft. distance. For a fixed telescope 1 : 100 or 1 : 150 would be preferred, according to the distances to be sighted and the length of the rod to be used. A prism throwing 1 : 150 will permit readings at 1,500 ft. on an 11 ft. rod, while a 1 : 100 prism will read only to 1,000 ft. on the same rod. On the other hand, where a standard steel tape with sliding targets is used instead of a rod, we may say that the wider angle prism will give more accurate work than the narrower.

*Choice of a Telescope.*—Since a large field is not needed, we have to deal with two considerations only—the lightness of the instrument and its power. If the former consideration governs the choice, I would recommend a light $d$ or a light 20 $d$ telescope; if the latter, I would recommend a 20 $d$ or a 30 $d$ telescope.

*Choice of Rods.*—In this direction I believe I have settled the question as regards the choice of a spacing rod with sliding targets; but I do not feel so sure with respect to the self-reading rods.

The spacing rod represented in Figs. 4 to 9 is so preeminently superior to every other which I have tried that I strongly recommend it.

This target stands out strong and bright under any circumstances It can be read against a dark background in the woods and also against a light sky background on a hilltop.

In Fig. 5 the rod is represented as seen by the eye. Fig. 6 shows it as seen by the prismatic stadia telescope. In this figure, *ud*, *ld* are the upper and lower images by the direct ray, and *ub*, *lb* are the upper and lower images by the bent ray. The observer of course neglects *ud* and *lb*, and uses for his contact *ub* and *ld*. The important advantages of this form of contact are shown in the subsequent figures.

Fig. 7 represents the targets approaching contact; Fig. 9 shows the images lapping, in which case there is a bright lens-shaped image, indicating the amount of

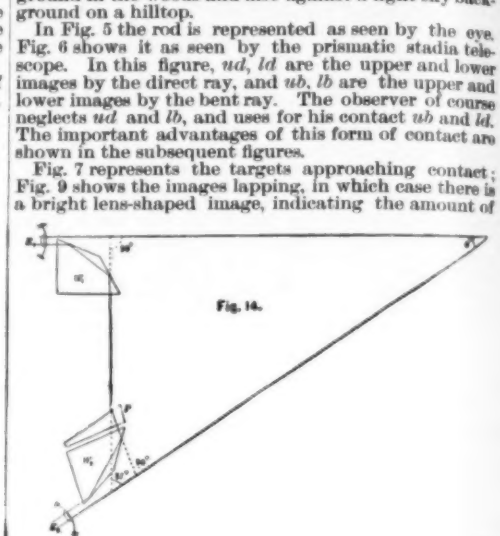


Fig. 14.

lap. Upon its appearance the assistant is signaled to draw the targets slowly apart; and the instant the white lens becomes invisible the reading, Fig. 8, is taken. The disappearance of this white lens gives a close and positive reading. The results stated below were obtained with this reading.

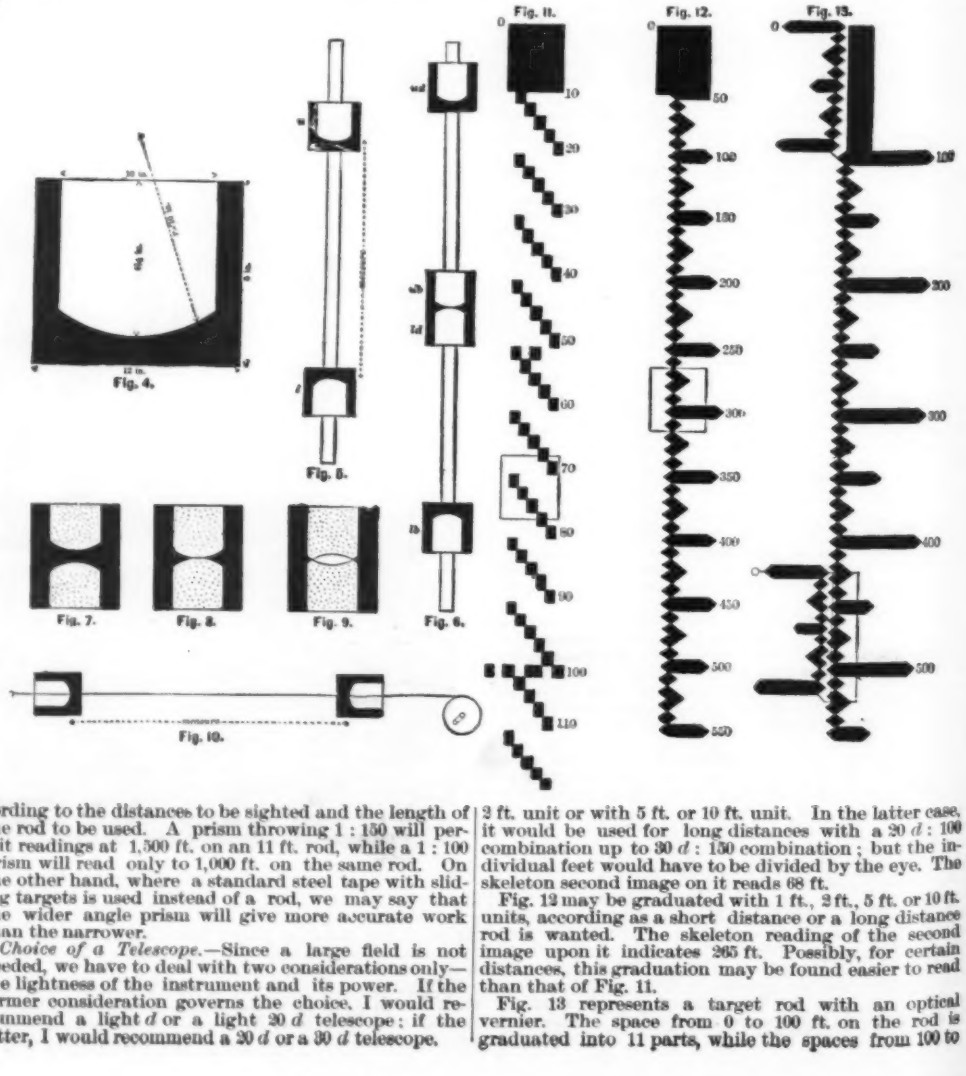
A target of the size shown in Fig. 4 can be read easily at 2,000 ft. distance with a 20 $d$ telescope, in an even atmosphere. A much smaller target will suffice for short sights. The design of Fig. 4 has more strong points in its favor than any other yet tried by me.

The spacing targets, Figs. 4 to 9, may be used on a steel tape if the following conditions are observed: The tape must be held at right angles to the line of sight. If the right angle is at one of the targets, it will be found easier to reproduce than at a point half way between the targets. For distances much greater than 2,000 feet a larger target or a higher power telescope, or both, will be needed.

Fig. 10 represents a tape, as used by me on a 1,970 ft. sight with the above targets and a 20 $d$ telescope.

*Self-reading Targets.*—Three forms which have been experimented upon are represented in Figs. 11, 12 and 13.

Fig. 11 gives good results with 10 $d$ : 50 combination for short distances. It may be graduated, as shown, with




2 ft. unit or with 5 ft. or 10 ft. unit. In the latter case, it would be used for long distances with a 20 $d$ : 100 combination up to 30 $d$ : 150 combination; but the individual feet would have to be divided by the eye. The skeleton second image on it reads 68 ft.

Fig. 12 may be graduated with 1 ft., 2 ft., 5 ft. or 10 ft. units, according as a short distance or a long distance rod is wanted. The skeleton reading of the second image upon it indicates 265 ft. Possibly, for certain distances, this graduation may be found easier to read than that of Fig. 11.

Fig. 13 represents a target rod with an optical vernier. The space from 0 to 100 ft. on the rod is graduated into 11 parts, while the spaces from 100 to

* A paper read at the Glen Summit meeting of the A. I. M. E., October, 1891.—*Eng. and Min. Jour.*

200, also from 200 to 300, and so on down, are graduated into 10 parts. Moreover, the space from 0 to 100, which we may call the vernier, is graduated on the opposite side to the other readings, so that the second image can bring it down and give a vernier reading between the two images. The partial skeleton second image gives a reading of 423 ft., no dividing by the eye being required. By this system an 11 ft. rod may be made for a 30 $d$ : 100 combination, which will actually give readings of individual feet at 1,000 ft. distance.

The vernier reading is the most fascinating idea I have met in my investigations. Whether it is really practical, can only be decided in the field. The images which are important for the reading are half light images, and therefore dim, while with the other two forms of target a full light reading is obtained.

*Limits of Error.*—Partly by reason of the limited time at my command for experiments, and partly because every time I went out to get definite records of practice, I made some discovery which led to an improvement in the apparatus, I can only promise at this time to give detailed figures at an early day as a supplement to this paper. The figures I am now prepared to publish were taken with a curved spacing target of the design shown in Figs. 5 to 9.

With a 20 $d$ : 150 combination, holding the rod at 100 ft. distance, I obtained five separate readings of the distance in feet between the targets, which were 0·653; 0·654; 0·653; 0·653; 0·653. With a 30 $d$ : 150 combination I made these four successive readings at 100 ft. distance: 0·675; 0·675; 0·675; 0·675; all with the spacing target described in Figs. 4 to 9.

If I had made an error of 0·001 ft. upon the rod, this would correspond to an error of 0·15 per cent. or 0·15 ft. in 100 ft. But I did not make this error in four readings with 30 $d$ : 150, and only made it once in five successive readings by the 20 $d$ : 150 combination. If the prism had been a 1 : 100 prism, the error referred to would have been 0·1 ft. in 100. If a prism had been a 1 : 50, the error would have been 0·05 ft. in 100 ft. I cannot imagine a reason why the percentage error at 1000 ft., or 2,000 ft., when the atmosphere is steady, should be any greater than it is at 100 ft. From the above considerations, I believe I am safe in saying that the error of the prismatic stadia is well inside of 0·1 per cent.

I hope to present, in the near future, some figures actually obtained for both short and long distances.

If one desires to determine the distance to a point without the trouble of sending an assistant there, it may be done with a pair of Wollaston camera lucidas, as shown in Fig. 14, in which $W_1$ $W_2$ are the two cameras.

If the Wollastons both give 90°, then the requisite deviation from 90° may be obtained by inserting a prism, P, as shown. If, however, the two Wollaston angles add up to say 177° to 178°, then the apex angle will be 2° or 3°, and will answer without the addition of another prism. After the two observers, $E_1$ $E_2$, have found their places, so that their respective images coincide, then they can measure the base line between them by a prismatic stadia telescope; and knowing the factor of the Wollastons, 3 ft. or 4 ft. to the hundred, the distance to the unknown point may be determined approximately by multiplying the observed distance between $E_1$ and $E_2$ by the factor, 3 ft. to 100; 50 ft. to 1,000; 300 ft. to 10,000, and so on.

In making my designs and in testing my instruments, I have been helped materially by Capt. A. H. Russell and Messrs. J. Hays Gardiner, W. H. Weston, Franklin Knight, Louis T. Verges and W. S. Hutchinson, friends to whom I wish to make acknowledgment.

## PARKINSON'S OXYGEN GAS PROCESS.

THE value of oxygen gas in certain industries and for professional use in some well known directions has led to several attempts to produce it economically, so that it might be sold cheaply. At the present time it would appear that these two conditions are not met in a way which will allow the gas to be used in many cases where it otherwise would be employed, besides rendering it costly when necessity obliges its use. The barrier to the more general use of oxygen, however, appears to have been effectually removed by a new process of manufacture which has been invented and put in practice on a working scale by Mr. J. H. Parkinson. This process we recently had the opportunity of inspecting at the works of Parkinson's Condensed Gas Company, of Stretford, Manchester. The chief difficulty which appears to have hitherto stood in the way of economical manufacture has been the want of a substance which would be unaffected by moisture or carbonic acid. A material which partly overcomes this difficulty has been found by Mr. Parkinson, and he, moreover, makes it highly porous, which permits the air, when passed over it, to permeate the mass thoroughly, and to come freely in contact with the chemicals. The material by which it was found that the necessary conditions were best satisfied is permanganate of potash prepared in a special manner, and it is by the aid of this that Mr. Parkinson extracts oxygen from the atmosphere and supplies it compressed in steel cylinders in a high state of purity for general use, which includes small consumers. Oxide of baryta has hitherto been largely used for the preparation of oxygen, and it was the disadvantages possessed by it which it was desired to avoid. These disadvantages are the absorbing of moisture and passing from the state of oxide to that of hydrate. Precautions, therefore, have to be taken to extract all moisture from the air previous to its passage over the baryta. If this is not thoroughly done, the fragments of baryta gradually unite into large masses of considerably less porosity than they originally possessed, and which are also chemically spoiled.

By employing permanganate of potash to effect the separation of the oxygen from the atmosphere it is found unnecessary to dry the air before passing it over the chemicals, as the moisture in no way deteriorates them. It is of the greatest importance that the active reagent should be in as porous a condition as possible, and to this end the finely powdered permanganate of potash is incorporated with from 12 to 15 per cent. of its weight of a good quality of kaolin or china clay. These ingredients are worked up into a suitable consistency with water, and the mass is divided into small pieces, which are dried by the aid of a vacuum in a vessel the temperature of which is very gradually raised at first and slowly increased till it reaches about 100° C. By this means the composition assumes a highly porous and spongy state, combined with a solidity and firmness which enable it to be readily handled and transported without falling to pieces. The chemicals thus prepared are placed in a series of special retorts suspended from the roof of a gas furnace. The chamber in which they are placed in the present plant contains five retorts, one of which, however, serves as a superheater for the air, the remaining four being charged with chemicals. The apparatus employed is illustrated herewith, where Fig. 1 represents a retort, in part elevation and part section, while Fig. 2 shows the whole apparatus in plan. The retorts are made of cast iron, and each forms practically a large U tube having an internal pipe or flue in each limb of the U in a vertical direction, extending from the lower end to the upper. The hot gases of the furnace have free passage through this flue, and so insure the heat of the furnace being readily communicated to the whole of the chemicals contained in the retort, each one of which (as at present made, but which can be enlarged if found desirable) will hold about 7 cwt. of the permanganate compound. The conduction of the heat into the heart of the chemicals is further facilitated by having a number of parallel belts and other projections formed round the circumference of the retort, which assist by conveying the heat to keep the whole at a uniform temperature. The temperature required in the furnace to insure good results is found not to be higher than a dull red, and insufficient to cause the retorts to be injuriously affected either by the heat or oxidation consequent thereon during long periods of time. The whole process of causing the chemicals to absorb the oxygen from the atmosphere and to subsequently evolve the same is automatic in its action, with the exception of the firing of the furnace and boiler.

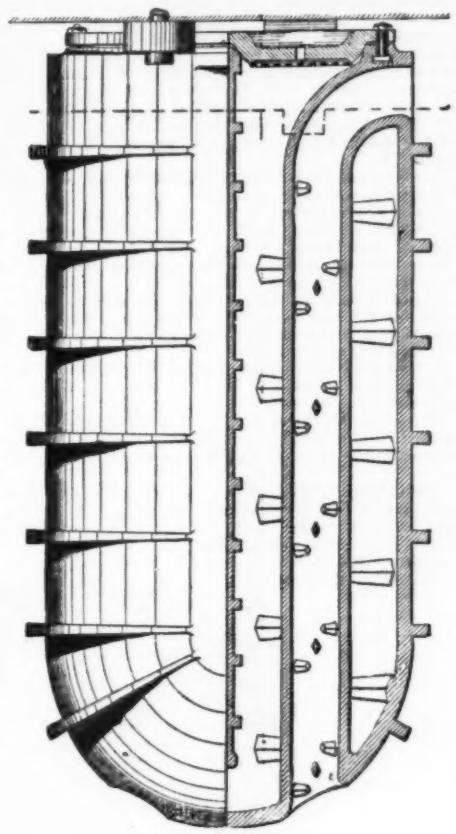


FIG. 1.

The detail arrangements of the apparatus are as follows: On the top of the furnace and resting on girders, which also form the supports from which the retorts are hung, are fixed on opposite sides two sets of compressing and vacuum pumps. These pumps are in close proximity to their work, thus dispensing with a large amount of communicating piping, and therefore in like proportion diminishing the risk of dilution of the oxygen produced by residual nitrogen in this piping. But one great advantage is gained by the use of the large retorts, as only sixteen lids and pipe joints at the mouths of the retorts have to be made and kept perfect, as against twelve times that number for a similar quantity of chemicals with smaller retorts. All the joints are placed so as to be accessible and readily examined, and the quantity of piping used reduced to the greatest possible extent, to insure a rich product. Each set of pumps (and which may be worked alone or in unison with the other) consists of a series of three cylinders, placed vertically side by side, and having 2 ft. stroke. The exterior ones form the pumps for delivering the air under pressure to the retorts, and the central cylinder in each case acts as the vacuum pump. The air is drawn by the pumps through a vessel containing lime, as while moisture has no deleterious effect on the chemicals, it is found desirable to extract any acids there may be in the atmosphere before allowing the air to pass through the retorts. As, however, the carbonic acid in the atmosphere amounts only to about one part in ten thousand, half a ton of lime either in the hydrate or as quicklime will do duty for an indefinitely long period.

The pumps then deliver the air, which, in consequence of the compression it has received, has had its temperature considerably augmented, into the first of the five retorts, passing on its way, however, after leaving the pumps, through a vessel containing caustic soda, which purifies it from any oily matter with which it may have become contaminated in its passage through the pumps. This first retort to which it passes, as before mentioned, contains no chemicals, and is simply a superheater, enabling the oxygen to be produced with a much lower furnace temperature, and therefore more economically, than if it were absent. The remaining four retorts are arranged in a series of two pairs, and so connected that while one pair is absorbing oxygen from air under pressure, the other pair is evolving oxygen due to the operation of the vacuum cylinders. There is, therefore, practically a continuous, and not merely an intermittent, flow of the gas. Air under pressure is constantly being delivered to the superheater and is directed by a valve into one pair of the retorts for about two minutes, the other two during this period giving off their oxygen. At the end of this time the air is automatically directed to the other pair of retorts, and those just relieved from pressure at the same time become connected with the vacuum cylinders and so on as long as desired. The pressure at which the air shall pass through the retorts is regulated by two small valves operated by springs, which open and allow the nitrogen to escape into the atmosphere at any predetermined pressure; from 5 to 10 lb. per square inch being found in practice to give good results. When drawing off the oxygen, all that is evolved passes through an apparatus known as a separator, which allows it and the nitrogen to escape into the atmosphere until a vacuum of about 25 inches is indicated, when the gas is then turned automatically into the holder.

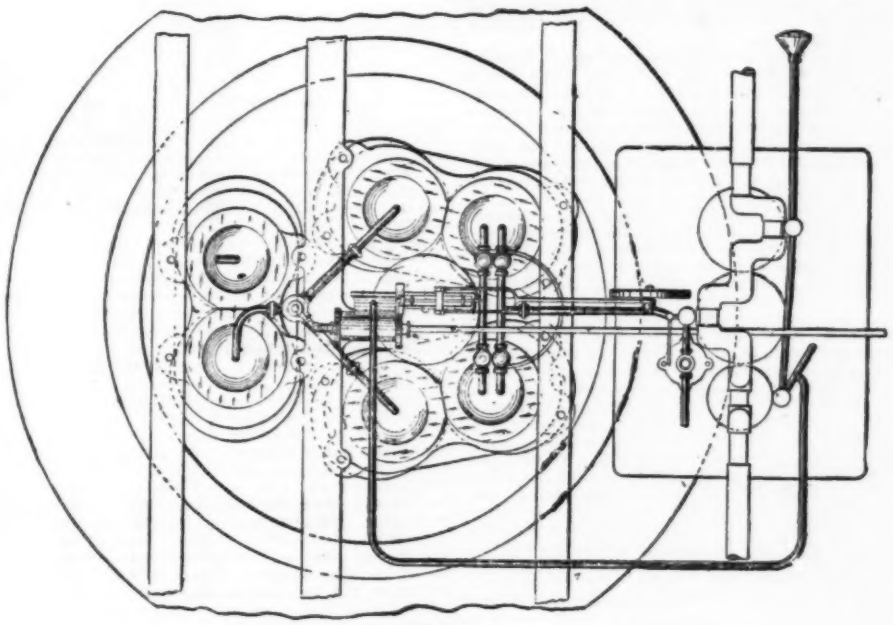


FIG. 2.

PARKINSON'S OXYGEN GAS APPARATUS.

As regards the output of the apparatus, we may mention that, owing to the manufacture having only recently been started, the company is not at present in a position to state absolutely the capabilities of the plant. Experience so far, however, is said to justify the following statement, which must be taken as representing only half the producing power of the whole, as two out of the four retorts charged with chemicals have exhibited defects, which has rendered it necessary to throw them out of work for a time. The two retorts now working yield a quantity of oxygen, with only one set of pumps in operation, amounting to 7,500 feet per twenty-four hours, and when the double set of pumps is in operation the production is 15,000 feet per diem. The expenses of the

plant, including depreciation, may be set down at £1 per day, assuming the price of coke on the premises to be 7s. 6d. per ton; one laboring man is capable of taking entire charge, the only work needed being attention to the fires and oiling of machinery, all else being automatic. Allowing a considerable margin for exigences, the expense per 1,000 feet is set down by the company at from 1s. to 1s. 6d. in the holder for gas in a high state of purity. In commercial processes, where so great a degree of purity is not essential, the cost would be materially reduced, and for many purposes it is stated that the cost of erection of a plant would soon be covered by the additional advantage gained by the use of oxygen over air. The size of plant to a certain extent governs the cost of the oxygen produced, the larger plants producing it the most economically, the cost also varying somewhat according to the prices of fuel and labor respectively in the localities under consideration. From what we have seen of this invention and its working, we consider that it marks an important advance in the commercial production of oxygen gas.—*Iron.*

## METALS AT HIGH TEMPERATURES.*

By Prof. W. C. ROBERTS-AUSTEN.

I PROPOSE this evening to consider, first, the methods of measuring high temperatures, and, second, to describe certain effects they produce on metals.

Geber, writing in the eighth century, gives directions for obtaining high temperatures, but points to the difficulties that arise in practice, "because fire is not a thing which can be measured, '*sed quoniam non est res ignis, quæ mensurari possit.*'"† It is not sufficient to attain temperatures that are known to be high; it is necessary, for the purpose of modern investigation, to measure them with accuracy; and few of the early chemists in this country did more in affording a basis for the study of metals at high temperatures than Robert Boyle, the application of whose well-known law to solutions of metals in each other has been made evident by recent work. The 30th of December last was the third centenary of his death; it is well, therefore, that this lecture should begin with a tribute to his memory. He suggested improvements in the ordinary mercurial thermometer,‡ constructed what would appear to be the first air thermometer with an index; and although he did not do much for thermometry at high temperatures, he appears to have been struck by what must have been a quaint device for regulating high temperatures, for he points out that "the great mechanic Cornelius Drebel § made an automatous musical instrument and a furnace which he could regulate to any degree of heat by means of the same instrument." He indicates various degrees of intensity of heat by reference to the color of a glowing mass of fuel, and says that, ‖ "though we vulgarly say in English 'a thing is red hot,' to express a superlative degree of heat, yet at the forges and furnaces of artificers, by a white heat they understand a further degree of ignition than by a red one." It is not a little strange that for three centuries after his death the same vague expressions have constantly been used in describing high temperatures.

A great step in advance was made in 1701 by Sir Isaac Newton, ¶ who applied the law of cooling to the measurement of temperatures beyond the range of the mercurial thermometer, and in the notes which accompany his "Scala graduum caloris" he showed that he knew that the freezing point of lead differs slightly from its melting point.

Eighty years later, Josiah Wedgewood (1782), ** aided by one of my predecessors, Mr. Alchorne, Assay Master of the Mint, determined a few melting points of metals, and in communicating a description of his "thermometer for measuring the higher degrees of heat" to the Royal Society, we find him, one thousand years after Geber had said that "fire cannot be measured," still lamenting the want of suitable instruments, saying: "How much it is to be wished that the authors [to whom he refers] had been able to convey to us a measure of the heat made use of in their valuable processes: . . . a red heat, a bright red, and a white heat are," Wedgewood adds, "indeterminate expressions; and even though the three stages are sufficiently distinct from each other, they are of too great latitude, and pass into each other by numerous gradations which can neither be expressed in words nor discriminated by the eye." Another ninety years brings us to the last time that the measurements of high temperatures formed the subject of a Friday evening discourse in this institution. On March 1, 1872, the late Sir William Siemens addressed you on the measurement of "heat by electricity;" †† and, speaking of the mercurial thermometer, said: "When we ascend the scale of intensity, we soon approach a point at which mercury boils, and from that point upward we are left without a reliable guide, and the result is that we find, in scientific books on chemical processes, statements to the effect that such and such a reaction takes place at a 'dull red,' such another at a 'bright red' or a 'cherry red' or a 'white heat'—expressions which remind one," he adds, "of the days of alchemy rather than of chemical science at the present day."

It is not a little singular that the same lament should have been uttered, with so long an interval between, by two prominent technical men, and it suggests that but little experimental work had been done in the meantime with a view to the measurement of high temperatures. This is, however, far from being the case. A vast amount of work was done by physicists and metallurgists whose chief masters were "indefatigable labor, the closest inspection, and hands that were not afraid of the blackness of charcoal;" and their more noteworthy efforts were based on the employment of the air thermometer, in which the expansion of air replaces the expansion of the mercury in the ordinary thermometer, the bulb being of some fire-resisting material.* For this purpose, Princep (1827) used a bulb of gold, Pouillet (1836) one of platinum, and finally, Deville and Troost, in a truly splendid series of investigations, adopted bulbs of porcelain, with iodine vapor as the elastic fluid. They ultimately reverted to the use of air.

You will remember that old mercurial thermometers had much information, supposed to be useful, engraved on their scales, and such statements as "water freezes," "water boils," "blood heat," "fever heat," "summer heat," were considered indispensable. It is by exposure to known temperatures that a thermoscope can be converted into a pyrometer for measuring intense heat; and the air or gas thermometer has, in the hands of Deville and Troost, rendered excellent service by enabling such gradations to be effected. The gas thermometer is not, in itself, a handy appliance, for it requires much subsidiary apparatus, and elaborate corrections of various kinds have to be introduced into the numerical data it affords; but it has given many fixed temperatures—such as melting points and boiling points of elements and of compounds—which may safely be made use of in graduating pyrometers. For very high temperatures, 900° C. and over, we rely on the excellent work of M. Violle† on the specific heats of platinum, silver, gold, palladium, and iridium, which have enabled the melting points of the respective metals to be calculated.

The determinations of temperatures between 300° and 1,000°, which are now generally accepted, also rest upon data accumulated by the aid of the air thermometer, which has thus enabled the graduation to be effected of instruments widely differing from it, that can be trusted to give rapid and accurate indications in daily use. I can only bring before you two of the many kinds which have been devised; they are, however, by far the best that are available, and for the determination of temperatures up to the melting point of platinum, leave to be desired—

1. A pyrometer which depends on the increase in the resistance of a heated conductor through which a divided electrical current is passing; and

2. One in which the strength of an electric current, generated by the heating of a thermo-junction, is used as a measure of the heat applied to the thermo-junction.

The principle of the electrical resistance pyrometer was indicated by Sir William Siemens ("Collected Papers," vol. ii. "Electricity," p. 84, 1889) in a letter addressed to Dr. Tyndall, dated December, 1860, and the nature of the instrument may be made clear by the accompanying diagram, Fig. 1. A divided current

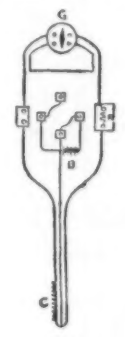



FIG. 1.

passes from the battery, B, to a platinum wire, C, coiled round a clay cylinder, and to a resistance coil, R. At the ordinary temperature the resistance of the platinum coil is balanced by the standard resistance, R. If, however, the platinum coil be heated, its resistance will be increased, and this increase of resistance, which can be measured in various ways, indicates the temperature of the coil, C. The coil itself may be adequately protected and exposed to temperatures which have been determined by the air thermometer; the deflection of a suitable (differential) galvanometer, G, will then indicate temperatures directly. For instance the temperature at which zinc boils has been accurately fixed at 940° C., and if the coil is heated in the vapor of boiling zinc, the angle through which the galvanometer mirror is deflected marks the temperature of 940° C.

The report of a British Association committee showed in 1874 that the instrument is liable to changes of zero, but Mr. H. L. Callendar has recently (1887) restored confidence in the method which had been shaken by the committee. He has proved that if sufficiently pure platinum wire be used, and if the wire be carefully annealed and protected from strain and contamination,‡ resistance pyrometers may be made practically free from changes of zero even when used at temperatures as high as 1,000° C. He attributes the changes of zero to which the Siemens pyrometers are liable to the action on the wire of the clay cylinder on which it is wound, and of the iron tube in which it is inclosed. As the result of his experiments he has introduced certain modifications, which render the instrument not only trustworthy but very sensitive. He winds the platinum wire on a thin plate of mica, and incloses it in a doubly glazed tube of hard porcelain. He uses the zero method of measuring the resistance; but for these and other details of manipulation his own very interesting papers must be consulted. I will only add that I have had the pleasure of working with him in the Mint Laboratory, and I am satisfied that at temperatures about 1,000° the *comparative* results afforded by his method are accurate to the tenth of a degree, a result which would certainly have been deemed impossible a year or two ago.§

The necessity for working with small volumes of fused metals, into which the tube of Callendar's pyrometer could not be plunged, has led me to prefer to adopt a method that would be classified under the second heading I have given. A very small thermo-junction may, in fact, be employed in such cases. The use of thermo-junctions for measuring high temperatures appears to have been suggested in 1826 by Becquerel, and adopted by Pouillet in 1836,* who advocates the use of iron in conjunction with platinum; but of all the varied combinations of metals and alloys which have been tried from time to time, that proposed by H. Le Chatelier possesses many advantages, on which I have elsewhere dwelt.† It consists of a platinum wire twisted at its end with a wire of platinum alloyed with 10 per cent. of rhodium. Such a couple may be used for some time without change of zero, and if the junction becomes injured it may be cut off, and the severed ends of the wires may be twisted together again. I am satisfied that it can afford comparative results which are accurate to 1° at temperatures of over 1,000°. The diagrams given later (Figs. 4, 5, and 6) show the disposition of the apparatus. The spot of light indicating the deflections of the galvanometer needle is caused, for the illustrations of this lecture, to fall on to a graduated scale 45 feet long on the wall of the theater. The thermo-junction has been calibrated with the aid of certain known temperatures, and the long scale is inscribed after the manner of the old thermometer scales, with certain fixed points, which are, of course, far higher than those it was possible to indicate by the expansion of mercury in a glass tube. [These fixed points were: "water boils" (100°), "lead melts" (326°), "zinc boils" (940°), "gold melts" (1,045°), "palladium melts" (1,500°), "platinum melts" (1,775°). On heating the thermo-junction to bright redness in a Bunsen flame, the spot of light moved rapidly to the point marked "zinc boils."] For laboratory experiments the scale is a short transparent one, rigidly fixed in relation to the galvanometer.

In leading up to the experiments which follow, in the course of which metals will be exposed to high temperatures, I would remind you that if an ordinary thermometer be plunged into water which is gradually losing its heat to a cold environment, the mercury will fall until the water begins to freeze, but directly this happens the mercury remains stationary until all the water is frozen; so that if the rate of fall be measured with a chronograph, there will be a steady fall to the freezing point of water, then a long arrest, followed by a renewed fall. If these readings be plotted, a well-known time temperature curve will be obtained. Exactly the same effect is produced when a fluid metal "freezes," and before proceeding further it may be well to determine experimentally the freezing point of gold. Beneath this little mass of pure gold, A (Fig. 2), a thermo-junction, B, is protected by a very thin

FIG. 2.

layer of clay from the metal. The oxyhydrogen flame is made to play on the gold, there is a rapid movement of the spot of light over almost twenty-five feet of the scale, there is a diminution in the rate of rise near the point marked 1,045°, the melting point of gold, and then, when the metal becomes fluid, the temperature rapidly rises as more heat is given to the little mass. The source of heat is now removed, the temperature falls, there is an arrest just at 1,045° C., the freezing point of gold, and then the spot of light resumes its course as the gold cools down to the temperature of the room. The melting point and freezing point of palladium, 1,500° C., were then shown in the same way. It should be observed, however, that when a small fragment of palladium is fused in the naked flame of the oxyhydrogen blowpipe, hydrogen appears to be absorbed by the metal; and this absorption of gas lowers the freezing point materially, and makes it far less steady than when a fresh piece of metal, cut from a large mass, is fused for the first time.

When the spot of light is allowed to fall on a sensitized plate in a suitable camera, ‡ the time temperature curve traced on a moving plate will be of the form shown in Fig. 3.

FIG. 3.

It may be useful to show the method by which these autographic curves are obtained. The following diagram, Fig. 4, is therefore added.

The arrangement consists in inclosing a galvanometer of the Deprez and d'Arsonval type in a large camera; a fixed mirror, F, being placed below the movable mirror, M, of the galvanometer, so that the

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* A lecture delivered at the Royal Institution by Prof. W. C. Roberts-Austen, C.B., F.R.S., on Friday evening, February 5, 1892.

† From the edition of his "Summa Perfectionis Magisterii," p. 28, published in Venice, 1542.

‡ Boyle's works, Shaw's edition, vol. i., p. 575, 1738.

§ Cornelius van Drebel, 1572-1634, *loc. cit.*, vol. iii., p. 38, 1738.

‖ *Loc. cit.*, vol. ii., p. 28.

¶ Phil. Trans. Roy. Soc., vol. xxii., p. 824.

** *Ibid.*, vol. lxxii., p. 305.

†† Roy. Inst. Proc., vol. vi., p. 438, 1872.

* See the excellent bibliography given by C. Barus, Bull. Geological Survey, U. S. A., No. 54, 1889.

† *Comptes Rendus*, vol. lxxxix., p. 702, 1879; vol. xcii., p. 865, 1881.

‡ Phil. Trans. Roy. Soc., vol. 178 (1887), A, pp. 161-230, and vol. 182 (1891), A, pp. 119-157; *Phil. Mag.*, vol. xxxii., July, 1891, p. 104, and vol. xxxiii., Feb., 1892, p. 220.

§ As this statement has been received with some surprise, it may be as well to state briefly how this degree of accuracy and sensitiveness is attained. The resistance box is compensated for changes of temperature, and changes of resistance in the wires leading to the pyrometer are automatically eliminated. The resistance itself is measured by a modification of the well known Carey-Foster method. The balancing resistance of the Wheatstone bridge employed is composed partly of resistance coils and partly of a bridge wire along which a contact key slides. The resistance of a centimeter of this wire is made to correspond to the increase of resistance of the pyrometer produced by a rise of 1° C. The galvanometer can easily be made sensitive to one-hundredth of a centimeter of this bridge wire, so that one-tenth of a centimeter, which corresponds to one-tenth of a degree, can, of course, be measured with certainty.

* *Comptes Rendus*, vol. lii., p. 782, 1836.

† British Association Lecture, *Nature*, vol. xli., 1889, pp. 11-32; Report Inst. Mech. Eng., Oct., 1891, p. 543.

‡ Proc. Roy. Soc., vol. xlix., 1891, p. 347.

light, from the lime cylinder, L, reflected in the mirror, E, passes to both mirrors, F and M, and is reflected in the direction of a fine horizontal slit, A B, behind which a sensitized photographic plate, C, is drawn vertically past the slit, by means of gearing, D, driven by clockwork. The ray from the fixed mirror is interrupted periodically by the vane, E, and a beaded datum line is given, which enables any irregularity in the advance of the plate to be detected.

The amount of divergence from its datum line of the spot of light reflected by the movable mirror at any given moment bears a relation (which can readily be found by calibration) to the temperature to which the thermo-junction, X, is heated, and the variations of temperature are recorded by a curve which is the resultant of the upward movement of the plate and the horizontal movement of the spot of light. A crucible, *c*, which may be filled with molten metal, is provided with a tubulure, T, for the insertion of the thermo-junction. The crucible is suspended by wires in a double jacket of tin plate, *a b*.

It will have been evident that the thermo-junction of platinum and platinum-rhodium could not be used for measuring temperatures higher than the melting point of the platinum of which it is made. Metals with higher fusion points than platinum are, however, available. Thus iridium will only just melt in the flame produced by the combustion of pure and dry hydrogen and oxygen. By the kindness of Mr. Edward Matthey, a thin rod of iridium has been prepared, with much labor, and it can be used as a thermo-junction with a similar rod of iridium alloyed with 10 per cent. of platinum. The junction may be readily melted in the electric arc, and by this means a temperature may be registered which careful laboratory experiments show to be close to 2,000°, and this agrees with the estimate of the melting point of iridium which Violle* deduced from calorimetric experiments. [This experiment was shown, a different scale being employed for the screen, as the thermo-electric constants of the iridium and iridium-platinum couple are different from those of the platinum and rhodium one previously used.]

It is interesting to remember that within a year in this institution temperatures ranging from −200° to +2,000° have been mapped out, the lower temperature by Prof. Dewar in his memorable Faraday lecture: the higher point is now measured in public for the first time.

How difficult it is for us to realize what this range of temperature really means, for we have but little power

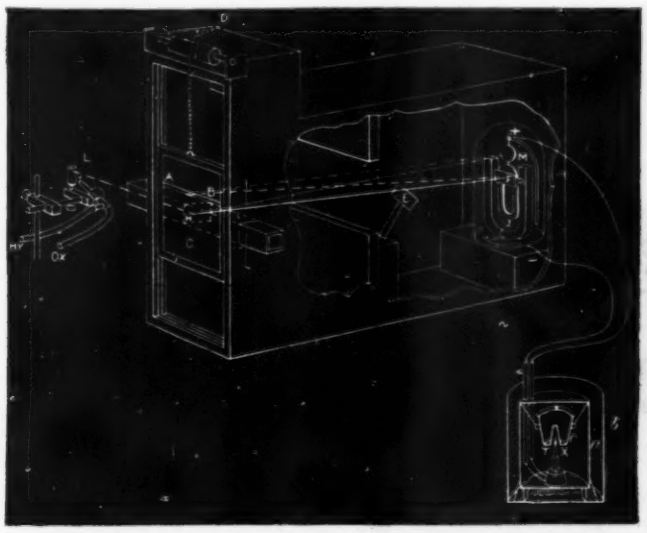


FIG. 4.

of appreciating temperatures beyond those we can conveniently bear. We, perhaps, know the meaning of extreme cold better than great heat, but even the vivid imagery of Dante, who might have been expected to afford some guidance, gives us singularly little help. I think in depicting the terror of torture inflicted by extreme cold he succeeds better than when he describes the suffering of those who are exposed to flames. His words (Canto xxxiii.):

"Blue, pinched, and shrined in ice the spirits stood"

mark the highest suffering drawn in the "Inferno." It is, however, probable that my failure to appreciate the descriptive powers of Dante may be the result of resentment, for I read with regret that he consigns to the tenth chasm of hell, not only the coiner who

"falsified
The metal with the Baptist's form impressed,"†

but also an honest metallurgist, Cappoccio, of Sienna, who

"by the power
Of alchemy . . . aped creative Nature by his subtile art;"

and, I think, deserved a better fate.

We are now in a position to consider certain other effects of high temperature on metals. Many years ago my colleague, Mr. Lockyer, and I conducted an investigation on the spectra of the vapors of certain metals ‡ at the highest temperatures we could produce, with the aid of the oxyhydrogen flame. We distilled silver, zinc, cadmium, and volatilized iron and other metals, from a lime crucible, and caused their vapors to pass into a horizontal tube of strongly heated lime. By these experiments we satisfied ourselves that the molecular structure of metals is gradually simplified as higher temperatures are employed; and we came to the conclusion that each molecular simplification is marked by a distinctive spectrum, and that there is also an intimate connection between the facility with which the final stage is reached, the group to which the element belongs, and the place which it occupies in the solar atmosphere. At the highest temperature of the oxyhydrogen flame, molecules of metals are simplified, but their constituent *atoms* remain unchanged. Mr. Lockyer has, however, since done far more: he has shown that the intense heat of the sun carries the process of molecular simplification much further; and, if we compare the complicated spectra of the vapors of metals produced by the highest temperatures available here with the very simple spectra of the same metals as they exist in the hottest part of the sun's atmosphere, it is difficult to resist the conclusion that the *atom* of the chemist has been itself changed. My own belief is that these "atoms" are changed, and that iron, as it exists in the sun, is not the vapor of iron as we know it upon earth. We will not dwell in this lecture on the effects of very high temperatures on metals, but rather on the influence of comparatively low temperatures—that is, below whiteness—in changing the number and arrangement of the atoms in metallic molecules. A profound change must occur when the viscous form of sulphur passes spontaneously at the ordinary temperature into the yellow crystalline variety, but the change is accompanied by but little thermal disturbance. In the case of metals there is also abundant evidence that molecular change may take place at low temperatures. Take the fusible alloy of bismuth, lead, and tin, which bears Newton's name, and contains:

| | |
|---|---|
| Bismuth | 50·00 |
| Lead | 31·25 |
| Tin | 18·75 |
| | 100·00 |

It fuses at 90°; it may be cast round a thermo-junction, and plunged in water and cooled thoroughly until the observer is certain that the mass has returned to the atmospheric temperature: take it out of the water, dry it rapidly, and in a few moments it will become too hot to hold. The "fracture" of the metal is totally different before and after the molecular change, which is the cause of this evolution of heat, has taken place. The change, moreover, takes place in the solid metal, and is not due to the release of the latent heat of fusion. The mass, solid as it appears to be, must be the scene of an internal struggle between the molecules in the effort to attain a state of equilibrium, and this conflict is but a type of the action that takes place in many metals and alloys which are of vast industrial importance.

Time will only permit me to deal with three cases of the action of high temperatures on atoms and molecules of metals. In the first case, the *arrangement* of the atoms in the molecule of a metal, iron, is disturbed, and the result is of great industrial importance. In the second case, the atoms of a metal, gold, appear to *combine* with those of another metal; and the result, while it is mainly of interest in connection with the history of science, has nevertheless an important bearing upon art. The third case relates to the *molecular bombardment* which takes place when a small quantity of metal is dissolved in a mass of a metallic solvent, and is of interest in connection with modern views both as to osmotic pressure and solution generally.

(1) The pyrometric couple is inserted in the center of a little mass of steel, which is being slowly raised to a bright red heat; when the flame is withdrawn, the spot of light will return toward the zero end of the scale, falling slowly until a temperature of 655° is reached, and then there will be an abrupt and prolonged arrest. The metal has never been near its melting point, and the evolution of heat must be due to a molecular change in the solid metal. In the case of this particular sample of steel, the evolution of heat is mainly the result of a change in the relation between the carbon and the iron; but by laboratory experiments and careful chronographic records, Osmond has shown that, in the case of certain varieties of steel, it can be demonstrated that what here appears as a single change, attended by an evolution of heat, is really an exceedingly complex one. I have shown that it occurs in the purest iron the chemists can prepare by electrolysis, and I agree with Osmond in believing that the change which occurs in pure iron at 855° is a molecular one, independent of the presence of impurity. If the mass of steel (Fig. 5, *a*) be heated again and allowed to cool, you will observe that the point of "recalescence" appears to be that at which the iron regains its magnetic property;* for a magnetized needle, *b*, is attracted at the moment the arrest of the spot of light on the pyrometer scale marks the temperature at which the change occurs, and at that precise moment a second spot of light from a mirror, mounted on the magnetic needle, will rapidly move away from its zero. I have elsewhere* dwelt

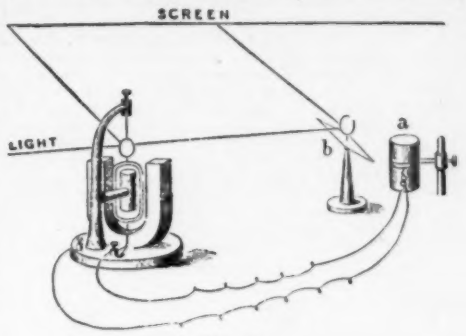



FIG. 5.

on the importance of the molecular change in iron and steel, and can now only summarize the significant facts.

It is unnecessary to point to the extreme industrial importance of the property steel possesses of becoming hard when it is quenched from redness in a fluid which will abstract its heat with more or less rapidity.

The changes which take place at 855° and 650° have to be arrested, as it were, by rapidly cooling the mass of steel; and if this is done, the steel will be more or less hard according to the rapidity with which the progress of the molecular change has been stopped. It is, however, useless to attempt to harden steel if the temperature of the mass has fallen below 650°. In "oil hardening" or cooling a large mass of steel, like the "A" tube of a gun, which may be 30 ft. long, great care should be taken to insure that the temperature of the mass is as uniform as possible; for, if part of the mass is hotter than 650°, while part is colder, the oil will really be cooling a mass of steel which is itself passing through various stages of complex molecular change, and the operation of "hardening" arrests, as it were, the atoms in the midst of a conflict incidental to their attempt to group themselves into one or other of the molecular modifications of iron. By cooling a mass of steel which is not at uniform temperature, stresses of great complexity and intensity are set up, stresses that may greatly reduce the effective strength of the gun.† The result is told in failures, by which many lives have been sacrificed; but I need hardly say that the Director-General of Ordnance is fully sensible of the national importance of studying the behavior of iron and steel at high temperatures, and, at Dr. Anderson's suggestion, the Institution of Mechanical Engineers appointed a committee, and have intrusted me with a large portion of the inquiry.

In the next experiment, Fig. 6, a bar (*a*) of steel, ½ in. in section and 18 in. long, was heated to bright redness and fixed firmly at one end; a weight of about 2 lb. is rapidly hung to the free end, a light pointer is added to magnify the motion of the bar, and the

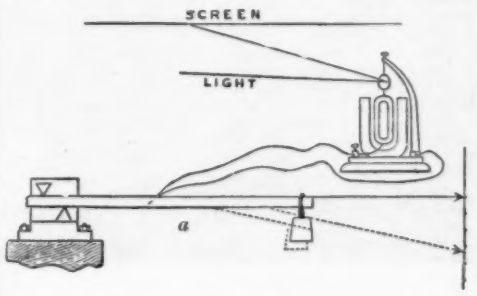



FIG. 6.

thermo-junction is rapidly introduced into a small hole drilled in what is arranged to be the hottest part of the bar. The bar is not softest at a red heat; it remains perfectly rigid until it has cooled down to dull redness, and the temperature, as measured by the spot of light from the galvanometer, shows that "recalescence" has occurred. At that moment of molecular weakness in the bar, the weight has power to bend it, and the pointer falls. By such experiments the exact temperature at which the metal becomes weak, in different varieties of steel, can readily be determined.

(2) Evidence will now be given in support of the second case it was proposed to treat, and it will be shown that at high temperatures the atoms of metals may truly combine with each other; in fact, taking gold as a basis for the experiments, compounds may be formed which would, had they been known centuries ago, have strangely affected the history of science. When the alchemists subjected the metals to high temperatures, their efforts were mainly directed to the discovery of some substance that would either change base metals to the color of gold, or would give them the brilliancy of silver. The mediæval chemists believed that there were two distinct substances that would effect this, "one for the white" and another "for the red." Many of their writings might be quoted in support of this view, but a reference to Geber, who wrote in the eighth century, will be sufficient. He pointed out that the transmuting agent "has a tincture of itself so clear and splendid, white or red, clean and incombustible, stable and fixed, that fire cannot prevail against it; . . . . and a property of the medicine is to give a splendid color, white or intensely citrine," to metals to which it is added.

* *Loc cit.*

† The golden florin of Florence.

‡ Proc. Roy. Soc., vol. xxiii., p. 344, 1875.

* The temperature at which these molecular changes take place in iron and steel was first demonstrated to an audience in my Newcastle lecture; 1889; but my friend, Professor Brinold, of the Royal Naval College, first arranged an experiment for lecture purposes which showed the magnetic change simultaneously with the thermal one.

* Report to the Institution of Mechanical Engineers, Proceedings, 1891, p. 543.

† "Internal Stresses in Cast Iron and Steel," by Nicholas Kalakoutsky, 1888.

That was the effect expected from the transmuting agent, but do not think that the attempt to produce gold arose entirely from the love of gain. The color of gold and purple impressed men strangely, and the search for the transmuting agent was most eagerly pursued in times when people lived for art, in a dream of color. The effort to find the secret of the tint of gold is due to the same impulse which made the French in the thirteenth century manifest a keen "sensitiveness to luminous splendor and intensity of hue," so that, as Sir Frederic Leighton tells us, "a stained glass window, by Cousin, was limpid with hues of amethyst, sapphire, and topaz, and fair as a May morning." The chemists were able to stain glass ruby and purple with gold: why should they not impart the same glories to metals? I could not hope to interest you in what follows, did I not call artists to my aid; and many will remember the glowing words Mr. Ruskin uses,* calling purple a "liquid prism and stream of opal," reminding us of the crimson and purple of the poppy, the scarlet and orange of fire and the dawn. No wonder he chides us with turning the lamp of Athena into the safety lamp of the miner, and with getting our purple from coal instead of, as of old, from the murex of the sea; "and thus grotesquely," he says, "we have had forced on us the doubt that held the old world between blackness and fire, and have completed the shadow and the fear of it by giving to a degraded form of modern purple a name from battle —'magenta.'"

You will remember that Faraday showed that gold, when finely divided, is brilliantly colored scarlet and purple. Here is a solution of chloride of gold. Add a little dissolved phosphorus, and the gold is precipitated in an extremely fine state of division, which tinges the solution crimson, but if you try to remove this suspended gold you will only gain a brownish mud. However, I will give you the secret by which any one who possesses a blowpipe, a bead of gold, and a fragment of one of the most widely diffused metals, aluminum, may stain gold purple through and through. But if you add aluminum to molten gold, you obtain many things, as this colored diagram and series of specimens show. [This diagram cannot be reproduced without color.]

The series of specimens showed that as the proportion of aluminum is increased, the golden color of the precious metal is lessened, and when an alloy is formed with about ten per cent. of aluminum, the fractured surface of the mass is brilliantly white; from this point forward, as aluminum is added, the tint deepens, until flecks of pink appear, and when seventy-eight parts of gold are added to twenty-two of aluminum a splendid purple is obtained, in which intense ruby-colored opaque crystals may readily be recognized. Then, as the quantity of aluminum is still further increased, the alloys lose their color, and pass to the dull gray hue of aluminum itself. Perhaps the most remarkable point about the purple alloy is its melting point, which I have shown to be many degrees higher than that of gold itself.† See diagram, Fig. 7,

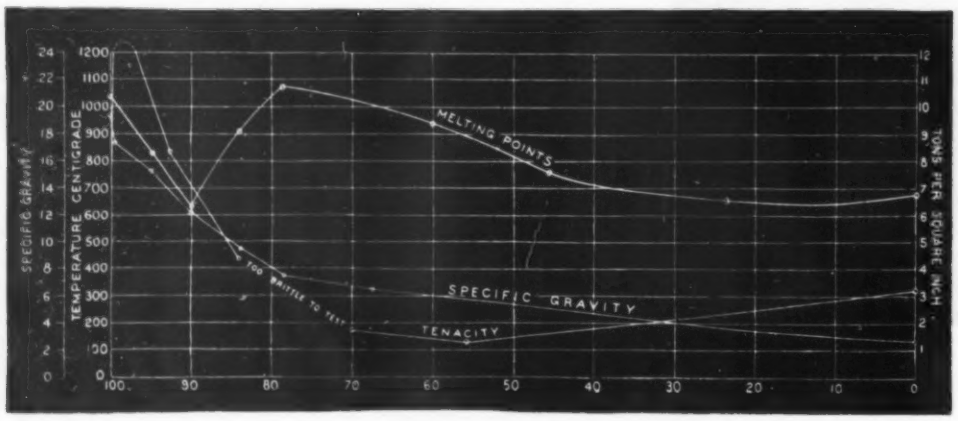



FIG. 7.

in which curves of several constants of these alloys are given. This fact affords strong evidence that the alloy $AuAl_2$ is a true compound, having analogies to the sulphides, for in every other series of alloys the melting points of all the members of the series are lower than that of the least fusible constituent. There is one other fact of much interest connected with this alloy. When it is treated with dilute hydrochloric acid, chloride of aluminum is formed, and gold is released in a singularly voluminous form. The heat of formation of the gold-aluminum alloy has not been determined, but hydrochloric acid, which will not attack gold, will readily split up this compound, of which more than three-fourths is gold; the compound, in fact, behaves like a distinct metal, having special heats of oxidation and chlorination of its own.

(3) Lastly, we come to the question of solutions of metals in each other. One very remarkable instance of the behavior of metals at high temperatures reveals the fact that the presence of a small amount of a metal in a mass of another lowers the freezing point of the mass. In the industrial world this has long been known. Cellini tells us, for instance, that when the bronze for his great figure of Perseus, at Florence, was running out of the furnace, it suddenly showed signs of setting, and he therefore threw pewter plates and dishes into the ducts through which the metal had to pass—"a thing," he says, "never before done." The fluidity of the metal was immediately increased, and he found every part of the casting "to turn out to admiration."

The excellent work of Heycock and Neville,‡ on the lowering of the freezing points of metals, by the addition of other metals, should, I would suggest, form the subject of a lecture in this institution at an early day.

I cannot attempt to deal with the matter here. In leading up to these questions of solution, as applied to metals, I would remind you that Lord Rayleigh told us a few evenings since that it was by no means certain that a gas rushing into a vacuous globe ever completely fills it, as there may still be tiny spaces into which "odd molecules" fail to find room to vibrate in. If it is difficult for a gas to entirely fill a vacuous space, you would think it impossible for a small quantity of a metal to rapidly permeate a fluid mass of another metal: nevertheless, so far as analysis can detect, this does happen.

It may be incidentally observed that the relations of the ordinary gases to metals are far more intimate than they were formerly supposed to be, and this was proved by Graham's work on the absorption of gases by metals, which has often been dealt with in this institution. To take only the case of iron, more than twenty years ago Sir Lowthian Bell showed that carbonic oxide can carry away iron, which is released when the temperature is raised. Ludwig Mond and Langer have since isolated most interesting compounds of iron and carbonic oxide. But to return to the solution of metals in metals.

The method of taking autographic curves of the cooling of masses of metal has already been indicated in Fig. 4,* and they ought to enable much information to be gained as to what is taking place throughout the mass. Such curves should render it possible to ascertain which of the rival theories as to the nature of solution, as applied to salts, is supported by the behavior of a metal dissolved in a metal. When, for instance, a little aluminum dissolves in gold, is the analogue of a hydride formed, and, if so, is the curve of freezing points of a series of aluminum-gold alloys a continuous one? On the other hand, does the theory advocated by van't Hoff, Arrhenius, and Ostwald gain support, and do the molecules of the dissolved metals act independently of the solvent—that is, does *osmotic* pressure come into play? It will be remembered that the law which regulates osmotic pressure has exactly the same form as Boyle's law—that is, the pressure is proportional to the density of the gas or of the solution. Is the view of Arrhenius correct—that, if a solution be very dilute, the molecules of the dissolved substance are dissociated, act independently of each other, and behave like a perfect gas?

It will require years of patient work before these questions can be answered; but it appears certain, from the admirable experiments of Heycock and Neville,† to which reference has already been made, that, taking metals with low melting points (such as tin or lead) as solvents, the lowering of the freezing point of the solvent is really due to the bombardment exerted by the molecules of the dissolved metals.

I have extended this investigation by employing as a solvent a mass of fluid gold, which has a high melting point, and is not liable to oxidation, and the results confirm those obtained by Heycock and Neville.

There is yet one other question: When metals are added in small quantities to a metallic mass, may the solvent remain inert? Here is a mass of 1,000 grammes of lead, and to it 15 grammes of gold, or 1·6 atoms for every 100 atoms of lead, will now be added. It could be shown that the gold is readily dissolved, and remains dissolved, even if the lead be solidified. Now, to the fluid lead sufficient aluminum will be added to form the purple alloy with the dissolved gold; the mass will be well stirred, but the aluminum will not unite with the lead; it will nevertheless find out the gold, and, after uniting with it, will carry it to the surface of the bath. Thence it can be removed, and the purple color of the alloy identified, or the gold it contains can be revealed by the method Prof. Hartley ‡ has given us for detecting the presence of gold in an alloy by volatilizing the alloy in a torrent of sparks from an induction coil, and condensing the vapor on mica.

The union of the aluminum and the gold must, however, be peculiar. Crookes § has shown that when this alloy is used as an electrode in a vacuum tube, the gold is volatilized from the alloy and deposited as a film on the glass, leaving the aluminum behind.

The purple alloy presents us with the most interesting case yet known of a molecule built up of purely metallic atoms, but we are certain that the atoms are still those of gold and aluminum—that is, the atoms of the united metals remain unchanged. The interest in this substance is deepened if it be remembered that our aim at the present is the same as that of the alchemists, for we are striving, as they did, to attack and change the chemist's *atoms* themselves. We seek, as truly as they, to effect the transmutations, which, as Boyle said, would "be none the less real for not being gainful," and employ high temperatures in the hope of simplifying the molecular structure of metals. We no longer consider gold to be the "sum of perfection," but still retain the belief expressed by Geber, eleven hundred years ago, that, "if we would change metals, we must needs use excess of heat." A poet also appears to have felt this, for George Herbert writes in the seventeenth century—

> "I know . . . what the stars conspire,
> What willing Nature speaks, what forced by fire;"

thus comparing the ordinary response of Nature to the investigator with the evidence he elicits from her by heat.

By fusing gold, and staining it "the purple of the dawn," a new interest has been given to the metal which the alchemists always connected with the sun; and for further proof that metallic atoms may be changed, we must turn to the sun itself, as to a great metallurgical center, where "all the elements shall melt with fervent heat."

* "The Queen of the Air," ed. 1887, p. 129; *Times*, December 11, 1891.

† Proc. Roy. Soc., vol. l., 1891, p. 367.

‡ *Chem. Soc. Jour.*, vol. lv., 1889, p. 666; vol. lvii., 1890, pp. 376, 656; vol. lix., 1891, p. 936.

* Proc. Roy. Soc., vol. xlix., p. 347, 1891.

† *Loc. cit.*

‡ Proc. Roy. Soc., vol. xlvi., 1889, p. 88.

§ Proc. Roy. Soc., vol. l., 1891, p. 88.

## EXPERIMENTS UPON SURFACE FILMS.

By Lord RAYLEIGH, Sec. R.S.*

THE experiments here described are rather miscellaneous in character, but seem of sufficient interest to be worthy of record. The greater number of them have been exhibited in the course of lectures at the Royal Institution.

### THE BEHAVIOR OF CLEAN MERCURY.

According to Marangoni's rule, water, which has the lower surface tension, should spread upon the surface of mercury, whereas the universal experience of the laboratory is that drops of water standing upon mercury retain their compact form without the least tendency to spread. To Quincke belongs the credit of dissipating the apparent exception. He found that mercury specially prepared behaves quite differently from ordinary mercury, and that a drop of water deposited thereon spreads over the whole surface. The ordinary behavior is evidently the result of a film of grease, which adheres with great obstinacy.

The process described by Quincke is somewhat elaborate; but my experience with water suggested that success might not be so difficult, if only the mistake were avoided of pouring the liquid to be tried from an ordinary bottle. In the early experiments upon the camphor movements, difficulty seems to have been experienced in securing sufficiently clean water surfaces. The explanation is probably to be found in the desire to use distilled water, and to the fact that the liquid would usually be simply poured from a stock bottle into the experimental vessel. No worse procedure could be devised, for the free surface in the bottle is almost sure to be dirty, and is transferred in great part to the vessel. In my experience water from the dirtiest cistern will exhibit the camphor movements, provided that it be drawn in the usual manner from a tap, and that the precaution be taken to give the vessel a preliminary rinsing.

In order to carry out the idea of drawing the liquid from underneath, an arrangement was provided like an ordinary wash bottle, and was filled with tolerably clean mercury. As experimental vessels watch glasses are convenient. They may be dipped into strong sulphuric acid, rinsed in distilled water, and dried over a Bunsen flame. When the glasses are cool they may be charged with mercury, of which the first portion is rejected. Operating in this way, there was no difficulty in obtaining surfaces upon which a drop of water would spread, although, from causes that could not always be traced, a certain proportion of failures was met with.

Exposure of the glasses to the atmosphere soon tells upon the success of the experiment, although on one occasion spreading occurred after a glass had stood (with protection from dust) for 20 hours. Even so short an exposure as 10 minutes was found to prejudice the condition of the mercury surface. Although something here may have depended upon the special character of the sample of mercury, it will be advisable in repeating the experiment to pour the mercury at the last moment.

As might be expected, the grease which produces these effects is largely volatile. In many cases a very moderate preliminary warming of the watch glass makes all the difference in the behavior of the drop.

So far as I have observed, the spreading of the drop takes place always in a leisurely fashion. If a little powder of recently ignited magnesia be dusted over the mercury, there is no violent repulsion of the dust before the advancing water. But if a small drop of oil be substituted for the water, the powder is flashed away so quickly that the eye cannot follow the operation. The difference between the two cases appears to depend upon the atmospheric moisture. As soon as the mercury is poured, it coats itself with an aqueous film, and the subsequent spreading of the drop takes place upon a surface whose affinity for water is already largely satisfied. A drop of water that has spread and then partially gathered up again (as usually happens after a short interval) shows an interesting behavior when breathed upon. The disk contracts somewhat, and then as the breath, which need hardly be visible, passes off, expands again, and thus a number of times. The temporary character of the effect indicates that it is due rather to the moisture of the breath than to any greasy contamination; a view confirmed by subsequent experiments, in which the breath was replaced by a current of pure air which had passed through warm water.

In the experiment with a powdered surface, the dust may be driven from the neighborhood of a drop of petroleum by the action of vapor without actual contact of the liquids.

### DROPS OF BISULPHIDE OF CARBON UPON WATER.

The behavior of a drop of $CS_2$ placed upon clean water is also at first sight an exception to Marangoni's rule. So far from spreading over the surface, as according to its lower tension it ought to do, it remains suspended in the form of a lens. And dust which may be lying upon the surface is not driven away to the edge upon the deposit of the drop, as would happen in the case of oil. A simple modification of the experi-

* Communicated by the author.

ment suffices, however, to clear up the difficulty. If *after* the deposit of the drop a little lycopodium be scattered over the surface, it is seen that a circular space surrounding the drop, of perhaps the size of a shilling, remains bare, and this, however often the dusting be repeated, as long as any of the $CS_2$ remains. The interpretation can hardly be doubtful. The bisulphide is really spreading all the while, but on account of its volatility is unable to reach any considerable distance. Immediately surrounding the drop there is a film moving outward at a high speed, and this carries away almost instantaneously any dust that may fall upon it. The phenomenon above described requires that the water surface be clean. If a very little grease be present there is no outward flow, and dust remains undisturbed in the immediate neighborhood of the drop. With the aid of the vertical lantern, and a shallow dish whose bottom is formed of plate glass, these experiments are easily shown to an audience.

### MOVEMENTS OF DUST.

When dust of sulphur or lycopodium is scattered upon the surface of water contained in a partially filled vessel, it is found that after a few seconds the dust leaves the edge and that a clear ring is formed of perhaps a centimeter in width. Two explanations suggest themselves. The action may be due to grease communicated to the surface from the edge of the vessel; or, secondly, it may be the effect of gravity upon those particles of the dust which lie within the limits of the capillary meniscus. The first explanation is rendered improbable by the non-progressive or at least but very slowly progressive character of the effect, and it is negatived by a repetition of the experiment in a varied form. It is found that if the vessel, whether of glass or metal, be filled *over the brim*, so that the capillary meniscus is convex, then, although as before a bare margin is formed, the effect is due to a motion of the dust outward (instead of inward, as in the former case), and therefore not to be attributed to grease.

A similar movement of dust was to be observed in the experiment above recorded, where magnesia was scattered upon a pool of mercury, and is undoubtedly due to gravity; but the full explanation is not so simple as might appear at first sight.

Even in the interior parts of the surface at a distance from the edge the sulphur particles do not retain their initial positions, but form aggregations into which continually increasing numbers are attracted. This is also due to gravity, neighbors tending, as it were, to fall into the depression by which every particle is surrounded.

### CAMPHOR MOVEMENTS A TEST OF SURFACE TENSION.

The theory of these movements, due to Van der Mensbrugghe, implies that they will take place with greater or less vigor so long as the tension of the surface, which may be in some degree contaminated, is greater than that of a saturated solution of camphor. If, however, the contamination be so great that the tension falls below this point, the solution of camphor can no longer spread upon the surface, and the movements cease. Thus, according to this theory and to observations* upon a saturated solution of camphor, the movements are an indication that the actual tension does not fall below 0·71 of that of pure water.

Although there appeared to be no reason for distrusting this view, it was thought desirable to examine specially whether the cessation of the movements was really a question of surface tension only, without regard to the character of the contamination. The readiest method of insuring the equality of the tensions of two surfaces contaminated with different materials is to make the two surfaces parts of one surface, for two parts of the same surface cannot be at rest unless they have the same tension. The method of experiment was therefore to divide a surface of clean water contained in a large dish into two parts by a line of dust, and to communicate different kinds of grease to the surfaces on the two sides of the indicating line. If, for example, a small chip of wood, slightly greased with olive oil, be allowed to touch one part of the surface, the line of dust is repelled by the expansion of that part, but the effect may be compensated by a slight greasing of the other part with oil of cassia. By careful alternate additions the line of dust may be kept central, while the two halves become increasingly greased with the two kinds of oil. At every stage of this process, so long as the surface is at rest, the tension of all parts is necessarily the same.

A large number of substances have thus been tried in pairs, of which may be mentioned oils of olive, cassia, turpentine, lavender, cinnamon, anise, petroleum, pseudocumene. In no case could any difference be detected in the behavior of camphor fragments on the two sides. Whenever possible, the quantities of oil were adjusted to the point at which the movements were just ceasing. In case of overshooting the mark, the excess of oil could be easily removed by strips of paper, partially immersed and then withdrawn, the action being equivalent to an expansion of the surface. In several cases the volatility of the substance with which the surface was contaminated led to a subsequent retraction of the line of dust. Thus freshly distilled oil of turpentine, even at first barely capable of arresting the movements, soon passes off.

As was shown by Tomlinson, oil of anise is incapable of arresting the camphor movements. In the experiment with a partition of dust, olive oil will drive oil of anise into a very small space, whose area is doubtless dependent upon the amount of other impurities present. In this case, as in all others, the behavior of camphor is the same on the various parts of the surface.

It may thus be taken as established that the relation of a contaminated surface to the camphor movements is one of surface tension only.

A similar method of experimenting may be applied to a rough determination of the degree of purity of cleansed surfaces. The whole of the surface under test is lightly dusted over, and olive oil is applied at several places close to the circumference until camphor movements are nearly arrested. After each addition of oil the dusted area contracts, and at the close of operations it gives a measure of the extent to which the original contamination must be concentrated in order to stop camphor.

* Phil. Mag., November, 1890.

A few numbers may be given as examples, although in all probability the result is influenced by a variety of circumstances. A circular area of 10 inches diameter, occupied by tap water, and cleansed by the flexible hoop described in former papers, was tested on July 28, 1891. The application of oil, just sufficient to stop the camphor movements, drove the dust into a central circular patch of 2½ inches diameter. When the surface was in its natural condition, unpurified by the action of the hoop, the central patch was about 5 inches diameter. These numbers, approximately verified on repetition, show that the natural surface was about 4 times and the purified about 16 times better than according to the camphor standard. The difference between the two cases is less than was expected, and would perhaps have been greater had distilled water been employed. It must be remembered, also, that contact with dust (sulphur) is unfavorable to the purity of a water surface. In a very good light a special dusting might probably be dispensed with, the motion of the surface being evidenced by inevitable motes.

If the dust be applied in the first instance to a small central patch, which is then touched internally with a very small quantity of oil, the expansion of the dust in the form of a ring is followed by a slight but unmistakable rebound. The effect appears to take place when the surface is very clean to begin with, and is then somewhat difficult of explanation. I am disposed to think that it must be attributed in all cases to initial contamination. This is concentrated in front of the rapidly advancing ring, and has not time to diffuse itself equally over the whole external area. Under the influence of inertia the expansion of the central area may then proceed so far that its tension becomes greater than that of the parts immediately surrounding.

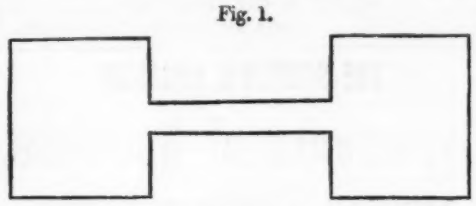
### INFLUENCE OF HEAT.

For a lecture experiment the effect of heat is best shown by holding a hot body near the surface of water contained in a shallow vessel with a glass bottom. The hot body may be the end of a glass rod heated by a flame, or, more conveniently, a small spiral of platinum wire, rendered incandescent at will by an electric current. The immediate effect of the heat is to lower the tension of the part of the surface affected; but the visible result depends entirely upon whether the surface be clean or otherwise. In the former case the heated surface expands, and an outward current is generated. This is rendered evident by the clearing away of dust. But if the original contamination exceed a very small quantity, a moderate expansion of the heated area brings the tension again up to equality with that of the surrounding surface, and there is no further action. In this case there is no visible clearing away of dust under the hot body.

Under favorable circumstances a very slight elevation of temperature suffices. On July 28 a shallow tin vessel 8×5 inches, the lid of a biscuit box, was leveled and filled with tap water from a rubber hose after thorough preliminary rinsing *in situ*. A little dust (sulphur) was then scattered over, and the finger was brought underneath into contact with the bottom of the dish. After about 20 seconds the dust opened out, and a bare spot was formed over the finger of about 1½ inch diameter. A spirit flame, applied for a few seconds under one end of the dish, cleared away the dust from the larger part of the area. If, when quiet was nearly restored, a little fresh dust was applied, and the experiment with the finger repeated, the effect was more pronounced than before, and the bared space much larger, showing that the treatment with the spirit flame had driven away most of the residual contamination.

The best effects were obtained with a dish somewhat larger than that above mentioned; and in subsequent experiments the difference of temperature between different parts was more readily maintained by the use of a vessel in which the main portions were connected by

Fig. 1.



a comparatively narrow channel. In this way the tensions of surfaces, contaminated in different degrees, may be equalized, the warmer, purer surface in one compartment balancing the colder but greasier surface in the other. And the actual temperature difference necessary for equilibrium gives a measure of the small difference of tensions to be compensated.*

When the surface of the liquid in the tin vessel is but very slightly greased, a spot can no longer be cleared by the warmth of the finger held underneath. Indeed the spirit flame itself soon becomes ineffective. And yet the greasing may be so slight that camphor fragments move with apparently unabated vigor.

It is of interest to compare the behavior of saturated solution of camphor with that of greasy water. The former can scarcely be brought to rest unless covered up. This is doubtless due to evaporation of camphor, aided by local draughts. A spirit flame drives away dust in a manner impossible in the case of a merely greasy surface, whose tension may nevertheless be decidedly higher than that of the camphorated water.

It may here be mentioned that the lowering of tension by camphor follows a different law from the lowering caused by soap. In the latter case the fall of tension requires time, and at the first moment of its formation a free surface has almost the tension of pure water. Similar experiments to those formerly recorded† with soapy water have shown that the ratio of tensions for pure water and for solution of camphor are the same at the first moment of the formation of a free surface as when the measures are conducted statically.

### SAPONINE AND SOAP.

A strong infusion of horse chestnuts allowed excellent bubbles to be blown, up to 4 inches or more in diameter. When the interiors of equal bubbles of soap and of saponine were brought into communication, the latter contracted and the former expanded, showing that the tension of the saponine film was the greater. In order to obtain equilibrium, the diameter of the saponine bubble required to be about half as great again as that of the soap bubble. These saponine bubbles exhibited the characteristic wrinkling, when caused suddenly to contract by withdrawal of part of the contained air.

The foaming of Highland waterfalls is doubtless attributable to dissolved vegetable matter. In the autumn of 1890 I had an excellent opportunity of observing these effects in the case of the river Creed at Stornoway. By the coalescence of smaller ones hemispherical bubbles of remarkable size, up to a foot or more in diameter, were frequently formed, and endured for a few seconds; and yet not the smallest bubble could be blown from a tobacco pipe. However, by collecting some of the foam and allowing it to subside, which took a good while, I obtained liquid from which bubbles could be blown with a pipe up to 4 inches diameter. But these bubbles behaved like soap, and not, as had been rather expected, like saponine, remaining perfectly light and smooth when the included air was rapidly withdrawn.

### SEPARATION OF MOTES.

In the course of some experiments last year, in illustration of Sir G. Stokes' theory of ternary mixtures, I had prepared an association* of water, alcohol, and ether, in which the quantity of alcohol was so adjusted that the tendency to divide into two parts was almost lost. As it was, division took place after shaking into two nearly equal parts, and these parts were of almost identical composition. On placing the bottle containing the liquids in the concentrated light from an arc lamp, I was struck with the contrast between the appearance of the two parts. The lower, more aqueous, layer was charged with motes, while the upper, more ethereal, layer was almost perfectly free from them. Some years ago I had attempted the elimination of motes by repeated distillation of liquid in vacuum, conducted without actual ebullition, but I had never witnessed as the result of this process anything so clear as the ethereal mixture above described.

The observation with the ternary association, which happened to be the first examined, is interesting, because the approximate equality of the liquids suggests that the explanation has nothing directly to do with gravitation. But the presence of alcohol is not necessary. Ether and water alone shaken together exhibit the same phenomenon. It would appear that when the two liquids are mixed together in a finely divided condition, the motes attach themselves by preference to the more aqueous one, and thus when separation into two distinct layers follows, the motes are all found below.

An obvious explanation, which, however, stands in need of confirmation, is that under the play of the capillary forces the energy is least when the motes, which may be presumed to be denser than either liquid, are in contact with the denser rather than with the rarer of the two. The density here referred to is that which occurs in Laplace's theory of capillarity, and may need to be distinguished from ordinary mechanical density.

I have lately endeavored to obtain some confirmation of the views above expressed by the use of other liquids. It would evidently be satisfactory to exhibit the selection of motes by the upper, instead of by the lower, layer. Experiments with bisulphide of carbon and water and also associations of these two bodies with alcohol, which acts as a solvent to both, gave no definite result, perhaps in consequence of a tendency to the formation of a solid pellicle at the common surfaces. But with chloroform and water, and with associations of chloroform, water, and acetic acid (acting as a common solvent), the experiment succeeded. The motes were always collected in the *upper*, more aqueous, layer, even when the composition of the two layers into which the liquid separated was so nearly the same that a few additional drops of acetic acid sufficed to prevent separation altogether.

In this and similar cases a marked tendency to foaming may be observed when the composition is such that separation just fails to take place.

### THE LOWERING OF TENSION BY THE CONDENSATION OF ETHER VAPOR.

The suspension of water in an inverted tube of small bore is familiar to all. The limit of diameter was investigated some years ago by Duprez.† A glass tube,

Fig. 2.

such as that shown in Fig. 2, is ground true at the lower end, and at the upper end is connected to an

* The lowering of tension per degree Cent. is said to be 0·0018 of the total value.

† Proc. Roy. Soc., March, 1890.

* *Association* is here employed as a general term denoting the juxtaposition of two or more fluids. Whether the result is a *mixture* depends upon circumstances.

† "Sur un cas particulier de l'equilibre des liquides," *Bruxelles Acad. Sci. Mem.*, xxvi., 1851; xxviii., 1854.

India rubber tube provided with a pinch cock. Water is sucked up from a vessel of moderate size, the rubber is nipped, and by a *quick* motion the tube and the vessel are separated, preferably by a downward movement of the latter. In this way of working Duprez found that the liquid might remain suspended in tubes of diameter up to 16 millim., and with the aid of a sliding plate up to 19·35 millim. The theory is given in Maxwell's article in the *Encyclopedia Britannica* ("On Capillary Action"). For lecture purposes it is well not to attempt too much. The tube employed by me had an internal diameter of 14¼ millim., and there was no difficulty in obtaining suspension. The experiment on the effect of ether vapor was then as follows: The inverted tube, with its suspended water, being held in a clamp, a beaker containing a few drops of ether was brought up from below until the free surface of the water was in contact with ether vapor. The lowering tension, which follows the condensation of vapor, is then strikingly shown by the sudden precipitation of the water.

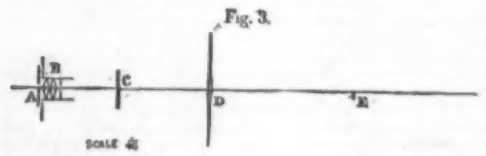
### BREATH FIGURES AND THEIR PROJECTION.

These figures are perhaps most readily prepared upon the plan described in Reiss' "Electricity." The carefully cleaned glass plate upon which the image is to be received is placed upon a flat metallic slab, and upon it again rests the coin to be copied, for example, a shilling. The two conductors form the coatings of a Leyden jar, and are connected by wires to the discharging terminals of a large Wimshurst machine, the latter being set so as to give sparks about ¼ inch long. In my experiments about twenty turns of the handle were found sufficient to impress the latent image.

The projection of the figures, developed upon the glass by breathing, requires a special arrangement, which it is the principal object of this note to describe. For this purpose the light simply transmitted by the undimmed parts of the plate must be intercepted, leaving the image to be formed by the light *diverted* from its path by the condensed breath. The arrangement was as follows:

The ordinary condenser, B (Fig. 3), of the electric

Fig. 3.




SCALE ½

lantern was stopped down to an aperture of ¾ inch, and provided a somewhat divergent beam of light of corresponding diameter. At a distance of 15½ inches from the condenser was placed the slide, C, upon which a figure had been impressed. The focusing lens, D, was of plate glass, 6 inches in diameter and 25 inches focus, and was of course distant from the breath figure by an amount slightly exceeding its own focal length. Any light that might pass outside was intercepted by a suitable mounting. So far there was nothing peculiar, except in respect to the dimensions of the focusing lens. But now between the latter and the screen was inserted a disk, E, of black card 2 inches in diameter, at such a distance (40 inches) from the lens as to receive a well defined image of the hot carbons, A. By this disk all regularly refracted light would be stopped, so that the screen would appear dark. If, however, any part of the prepared glass be dimmed by the breath, light is there diverted from its path, and thus escaping the stop, proceeds to form an image of the part in question upon the screen. The dewed parts of the breath figure are accordingly seen bright upon a dark ground; and with the arrangement described, in which the large diameter of the focusing lens is a leading feature, the projected images are very beautiful. A similar method would probably be adequate to the projection of smoke jets.

In conclusion I may mention that the latent images can be developed in a more durable manner by a deposit of *silver*, the arrangements being such as are adopted for the silvering of mirrors, except that the action is stopped at an earlier stage. The washed and dried deposit may then be protected from mechanical injury by a coat of varnish.

March 4, 1892. —*Philosophical Magazine.*

## TALC—FRENCH CHALK.

IN the matter of the protest of J. S. Kirk & Co., against the decision of the Collector of Customs at Chicago, as to the rate and amount of duties chargeable on certain talc (French chalk), imported per Arcadia, July 9, 1891, the following is the opinion by General Appraiser Wilkinson:

The merchandise is a ground mineral invoiced as talc. It was assessed for duty as French chalk at 1 cent per pound, under paragraph 16, N. T., and is claimed by the appellants to be dutiable as a mineral advanced in condition at 20 per cent., under section 4, act of October 1, 1890.

A sample of the article was submitted to the chemist of the United States laboratory at this port, who reports as follows:

Analysis.—Water, 9·40 per cent.; silica, 47·32 per cent.; alumina and oxide of iron, 3·53 per cent.; lime, 28·37 per cent.; magnesia, 11·44; total, 100.

The same constitutes a ground mineral substance consisting of hydrous silicate of lime and magnesia, and, in my opinion, somewhat resembles French chalk, and might be used as such for some purposes. French chalk usually consists of talc or hydrous silicate of magnesia.

The constituents of steatite, talc, soapstone, or French chalk, as given in the American Encyclopedia, are: Silica, 62·14; magnesia, 32·92; water, 4·94.

We find upon the analysis of the United States chemist (1) that the merchandise in question is not French chalk.

Classification as French chalk under the similitude clause remains to be considered. In the authorities consulted, Ure's Dictionary, the British Encyclopedia, the Century Dictionary, and other standard works, there is no mention made of the use of French chalk in the manufacture of soap. In the present case the appellants testify that the mineral is for use in the manufacture of soap; nor have we any information as to what, if any, purpose this mineral may be used as French chalk is.

We find (2) that the merchandise in question is not similar to French chalk in material, quality, texture, or the use to which it may be applied.

We hold that the article is a non-enumerated article, manufactured in part, and the claim of the appellants that it is dutiable at 20 per cent., under section 4, is hereby sustained.

THE electrical instrument recently invented for avoiding the pain incident to the extraction of teeth has attracted considerable attention. Briefly, it consists of adjustable prongs, carrying buttons and connected with an electrical battery. The buttons are placed on the face over the nerves leading from the teeth to the brain, and a circuit is established the moment the extracting instrument touches the tooth.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